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Canadian Stock Assessment Secretariat
Research Document 99/178

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Secrétariat canadien pour l'évaluation des stocks
Document de recherche 99/178

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Stock Assessment for British Columbia Herring in 1999 and Forecasts of the Potential Catch in 2000

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ISSN 1480-4883
Ottawa, 1999
Canada

ABSTRACT

Herring stock abundance in British Columbia waters was assessed for 1999 and forecasts were made for 2000 using two analytical methods: (1) escapement model; and (2) age-structured model. These models have been applied to assess herring abundance since 1984 and no significant changes were implemented in either model in conducting the current assessment. All available biological data on total harvest, spawn deposition, and age and size composition of the spawning runs were used to determine current abundance levels. No significant problems were evident in the extent and comprehensiveness of the data collections. Coastwide, the estimated pre-fishery stock biomass for all assessment regions in 1999 was 187,500. This represents a 2 percent decrease from 1998 abundance levels. This slight decrease reflects the recruitment of a poor 1996 year-class in 1999 in most areas of the coast.

Forecasts of the pre-fishery spawning stock biomass in 2000 are presented for both models. Stock forecasts for the northern stock assessment regions are 120,000 and 83,000 tonnes for the southern regions assuming average recruitment to all areas based on the age-structured model.

The estimated harvestable surplus in 2000 (20 percent of the 2000 forecast herring run) is 40,500 tonnes for the entire B.C. coast assuming average recruitment to all areas. However, since consensus on stock levels for each assessment region may change as a result of PSARC review of these data, forecast run sizes, and harvestable surpluses, are subject to change.

RÉSUMÉ

L'abondance des stocks de hareng des eaux de la Colombie-Britannique a été évaluée pour 1999 et des prévisions ont été faites pour l'an 2000 à l'aide de deux méthodes d'analyse : 1) un modèle des échappées et 2) un modèle structuré par âge. Ces modèles ont été appliqués à l'évaluation de l'abondance du hareng depuis 1984 et aucune modification appréciable n'a été apportée à l'un ou l'autre des modèles au cours de la présente évaluation. Toutes les données biologiques disponibles sur la récolte totale, la ponte et la composition par âges et par tailles des remontées de géniteurs ont été utilisées pour déterminer les niveaux d'abondance actuels. Aucun problème appréciable n'a été décelé en ce qui a trait à l'étendue et à l'intégralité des séries de données. À l'échelle de la côte, la biomasse du stock avant la pêche, pour toutes les régions d'évaluation en 1999, a été estimée à 187,500 tonnes. Cela représente une diminution de 2 % par rapport aux niveaux d'abondance de 1998. Cette légère diminution reflète le recrutement de la faible classe d'âge de 1996 en 1999, dans la plupart des zones de la côte.

Des prévisions de la biomasse du stock de géniteurs d'avant la pêche obtenues à l'aide des deux modèles sont présentées pour l'an 2000. La valeur prévue obtenue est de 120 000 tonnes pour les régions d'évaluation du nord et de 83 000 tonnes pour les régions du sud, en supposant un recrutement moyen dans toutes les zones basé sur le modèle structuré par âges.

L'excédent estimé récoltable en l'an 2000 (20 % de la remontée de hareng prévue de l'an 2000) est de 40 500 tonnes pour l'ensemble de la côte de la Colombie-Britannique, si l'on suppose un recrutement moyen dans toutes les zones. Les valeurs prévues des effectifs des remontées et des excédents récoltables pourront cependant varier car le consensus établi pour les effectifs des stocks dans chaque région d'évaluation pourra être modifié suite à l'examen des données par le CEESP.

1. INTRODUCTION

Herring have been one of the most important components of the British Columbia commercial fishery over the past century with catch records dating from 1877. The fishery has evolved from a dry salted product in the early 1900s, to a reduction fishery in the 1930s that collapsed in the late 1960s. After a four year closure the current roe fishery began in 1972. Roe fisheries occur just prior to spawning when the fish are highly aggregated and very vulnerable to exploitation. Since 1983, herring roe fisheries have been managed with a fixed quota system. Under this system harvest levels are determined prior to the season based on a fixed percentage (20%) of forecast stock size. In addition, threshold biomass or Cutoff levels were introduced in 1985 to restrict harvest during periods of reduced abundance.

In this report, we present stock assessments from two analytical models which have been developed explicitly for British Columbia herring: (1) a modification of the escapement model described by Schweigert and Stocker (1988); and (2) a modification of the age-structured model described by Fournier and Archibald (1982). Both models reconstruct stock abundance for the period 1951-1999 and forecast pre-spawning abundance for the 2000 season. Forecasts of upcoming run size are based on the combination of estimates of surviving repeat spawners and newly recruited spawners which are presented as poor, average, and good, based on historical recruitment levels.

1.1. DATA BASE

The primary data sources for the stock assessments are spawn survey data, commercial catch landing data, and age composition data from biological samples of commercial fishery, pre-fishery charter, and research catches. These data are available on computer files for the period 1951 to 1999. This time span includes the reduction fishery period to 1968 and the subsequent roe fishery period which began in 1972.

Of the three data sets, the spawn data contain the largest measurement errors. While the quality of spawn surveys has generally improved over the 49 year span of these data due to increased effort and better quality control of the surveys, there are occasional problems with equipment and weather which may hamper data completeness and accuracy in some years. The consistent observations made during all years of surveys are the total length, the average width, and a measure of egg density for each spawning site. Since 1987 an increasing number of egg beds have been assessed using Scuba rather than traditional surface survey methods. We assume all surveys provide reasonably accurate estimates of spawn bed width and egg density and these data have been used in the escapement model where available. All major herring spawnings were surveyed in 1999, as were many of the minor spawnings outside the assessment areas. There is some concern that an unknown amount of deep spawning was not surveyed in Area 23. In addition, some light spawns in the Queen Charlotte Islands were not surveyed as were some portions of Area 27.

Catch information was obtained from landing slip data. Both models use the landing slip data summed by season (seasons run from July 1 to June 30). The 1997/98 catch figures are based on validated plant weights as a result of the introduction of the pool fishery for all areas except the Strait of Georgia and Prince Rupert gillnet fisheries. In 1998/99 validated plant weights are available for all food and roe fisheries coastwide. The spawn-on-kelp (SOK) fishery includes a total of 46 licensed operators who pond a substantial quantity of herring of which an unknown quantity dies each year. Since 1990, it has been assumed that the 100 tons (91 tonnes) allocated to each license are killed and this is treated as additional seine catch.

Age structure data are used in both models. The information from catch samples is used for years when there were commercial fisheries. Pre-fishery charters began in 1975 and these samples are used in addition to samples taken from the catch particularly in areas with no fisheries, or when catch samples are few in number or not representative of the entire catch. Additional data used in both models are annual mean weights-at-age. During the 1998/99 season a total of 308 herring samples (98 roe, 16 food, 147 test fishery and 47 miscellaneous others) were collected and processed compared to 400 in the previous year. Of the roe and test fishery samples, 30 were taken in the Queen Charlotte Islands assessment area (another 8 from Area 2W), 26 in the Prince Rupert area, 63 in the Central Coast, 58 in the Strait of Georgia, and 57 on the west coast of Vancouver Island (plus 3 from Area 27). Fourteen samples were obtained from SOK operations. We believe that this provides adequate coverage of all the assessment regions for the age-structured and escapement model assessment analysis.

In recent years, extended discussions regarding the adequacy of sampling coverage have occurred at the assessment review. In particular, it has been suggested that sampling inadequately covers the late stages of the spawning run thereby under-sampling the age 3 recruiting spawners. Appendices 3.1-3.5 display plots of the annually observed proportion at age in each sample by year and Julian day from 1971 to present. It is evident from these plots that with a few exceptions there is no evidence of significant time trends in the proportion at age for any assessment region suggesting that current sampling protocols accurately monitor the age composition of the catch and of the major spawning runs.

In the current assessment, we continue to use the year of life convention for ageing adopted in the 1991 assessment. Fish which were previously named age 3 are now referred to as the 2^{+} age class. In a few instances the text refers to age class 2^{++} which indicates all fish that are age 2^{+} and older.

1.2. STOCK CONSIDERATIONS

The stock concept used for managing British Columbia herring is based on current knowledge of stock structure which is necessarily incomplete. Given incomplete knowledge of population structure, it is prudent to manage fisheries to ensure maintenance of the greatest potential biological diversity. In addition, we do not feel that stock forecasts for smaller

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geographic regions than those used in the current assessments would be accurate enough for fisheries management. Therefore, we recommend that fisheries should continue to focus on the major aggregations within each assessment region to minimize the potential over-exploitation of any of the smaller, spatially discrete spawning groups. In the 1999 spawning season, a comprehensive research study was initiated using a combination of coded wire tagging and micro-satellite DNA analysis to further investigate stock structure of British Columbia herring. Preliminary results should be available within the next few years.

The stock groupings used for the current assessments are identical to those used since 1993 (Fig. 1.). The Queen Charlotte Islands stock assessment region spans from Cumshewa Inlet in the north to Louscoone Inlet in the south. The stock concept for the Prince Rupert District encompasses Statistical Areas 3 to 5. The Central Coast stock management unit separates the major migratory stocks from the minor spawning populations in the mainland inlets. The areas included in the Central Coast assessment region are Statistical Area 7 plus Kitasu Bay in Area 6 and Kwakshua Channel in Area 8. The Strait of Georgia stock includes all of Statistical Areas 14 to 19, and Deepwater Bay and Okisollo Channel in Area 13, and Areas 28 and 29. The west coast of Vancouver Island assessment region encompasses Statistical Areas 23 to 25. Haist and Rosenfeld (1988) outline current geographical stock boundaries.

Abundance estimates are not presented for other areas outside of the major assessment regions which may support additional small herring runs, because we believe that both the spawn survey and catch data are incomplete for many of these areas; therefore, presentation of stock estimates could lead to erroneous conclusions regarding either absolute abundance or stock trends. Recent attempts to conduct a complete age-structured assessment for Areas 2W and 27 have been unsuccessful. An escapement model estimate of current stock abundance is available for these areas but no forecast of abundance in the coming year is possible.

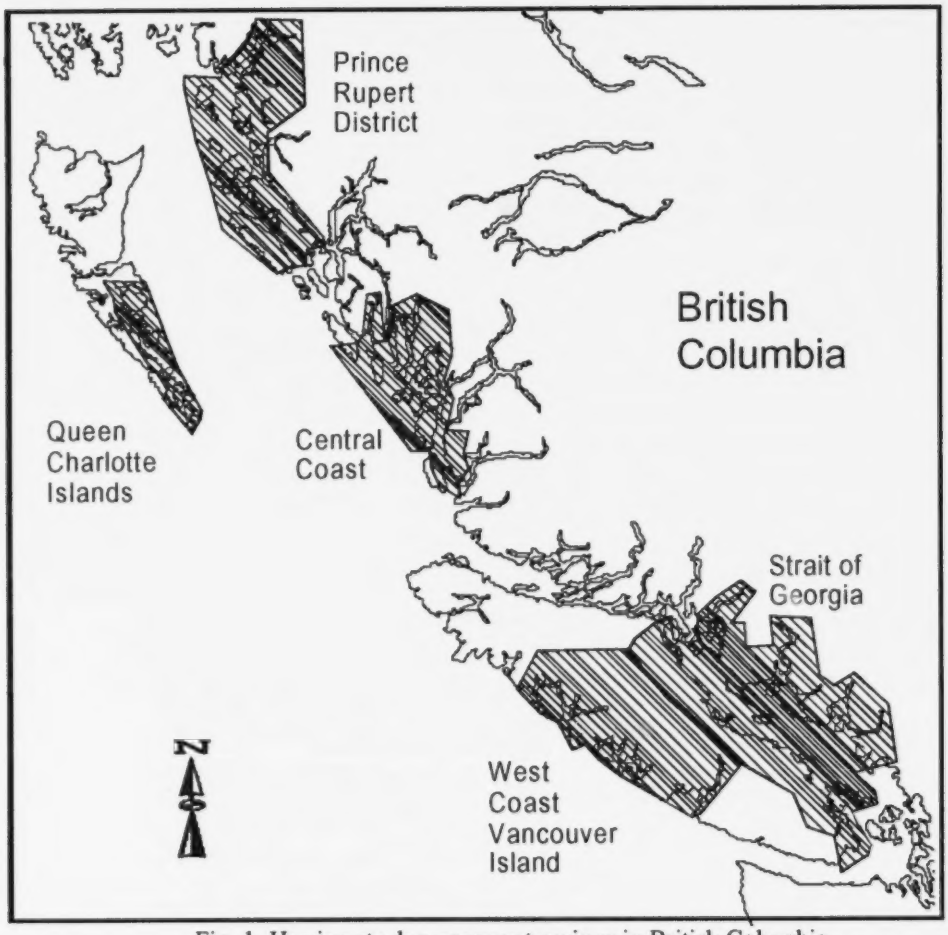

Fig. 1. Herring stock assessment regions in British Columbia.

2. ESCAPEMENT MODEL

2.1 INTRODUCTION

The escapement model, developed for the 1984 assessments (Haist et al. 1985; Schweigert and Stocker 1988), is based on egg deposition information and provides a direct estimate of escapement from the fishery. For most stock assessment regions, recent estimates of

escapement are based on a combination of surface and Scuba survey data. Scuba surveys have been used routinely since 1987 and an increasing proportion of the herring spawning beds have been surveyed using this technique. A summary of the recent spawn survey coverage for the British Columbia coast is presented below. As a result of reductions in DFO resources and the consequent contracting of diving surveys to industry, there was virtually no DFO effort directed to surface surveys in 1999, particularly outside of the assessment regions. No organized surface surveys were conducted in the Queen Charlotte Islands, Prince Rupert District, and Strait of Georgia. However, all areas did receive good Scuba survey coverage. Limited surface surveys occurred in the Central coast and Johnstone Strait, primarily outside of the major assessment areas. Coastwide there was an increase in the total length of spawn surveyed by Scuba and surface surveys relative to 1998. Most of the difference is attributable to the increase in spawning in Prince Rupert and surface surveys of Johnstone Strait which were not conducted in 1998 due to funding shortfalls.

Summary of the kilometres of herring spawning beds surveyed by Scuba and surface methods for major and minor stocks on the British Columbia coast in recent years, 1996-1999.

	1996			1997			1998			1999		
Assessment Region	Scuba	Surface	Total	Scuba	Surface	Total	Scuba	Surface	Total	Scuba	Surface	Total
Queen Charlotte Is.	25.3	0.0	25.3	36.4	0.0	36.4	58.4	0.0	58.4	42.1	2.4	44.5
Prince Rupert District	49.9	0.0	49.9	68.9	0.0	68.9	47.1	0.0	47.1	83.7	1.1	84.8
Central Coast	114.1	0.0	114.1	142.4	0.0	142.4	141.0	23.4	164.4	159.4	3.2	162.6
Strait of Georgia	128.4	3.1	131.5	119.1	3.5	122.6	140.8	6.2	147.0	133.8	3.5	137.3
W.C. Vancouver Is.	39.2	0.0	39.2	78.3	0.0	78.3	42.9	0.5	43.4	48.9	0.3	49.2
Other Areas	15.7	111.2	126.8	14.3	46.5	60.8	26.1	13.8	39.9	28.3	48.1	76.4
Coastwide Total	372.6	114.3	486.8	459.3	50.0	509.4	456.3	43.9	500.2	496.2	58.6	554.8

2.2 METHODS

In the escapement model, the forecast run size is based on the estimated escapement in the previous season, growth of the escaped fish during the current season, an age-specific apparent survival rate which accounts for both survival and partial recruitment of recruited year-classes, and an estimate of age 2^+ recruitment to each stock. Recruitment is estimated for poor, average, and good levels by calculating the means of the third poorest, the middle third, and the third best recruitments observed during the historical time series from 1951-1999. Estimates of total catch (tonnes) and spawn abundance (billions of eggs) are converted to fish-at-age based on the sampling data for each area. For each area, the age

structure and average weight-at-age are calculated from samples available for that region. In rare instances, no data are available for a region and information from an adjacent area is utilized in the analysis. Forecasts of repeat spawners and recruit fish are converted to forecast tonnages using average weights-at-age from the previous season.

Pre-Fishery Biomass and Spawn Index Estimates

Escapement from the fishery plus total catch provides an estimate of the pre-fishery spawning stock biomass for each assessment region. The following relationship may be used to estimate pre-fishery biomass for each area (Schweigert 1993) if all pertinent data are available:

$$B_j = C_j + Eggs_j \bullet \left(\frac{\sum_{3}^{10} P_{ij} F_{ij} SR_{ij}}{\sum_{3}^{10} P_{ij} W_{ij}} \right)^{-1}$$

where

B_j = total pre-fishery mature biomass in tonnes in year j,
C_j = total catch in tonnes in year j,
$Eggs_j$ = total egg deposition in billions in year j,
P_{ij} = proportion of fish at age i in year j in the spawning run,
F_{ij} = fecundity of females of age i in year j,
SR_{ij} = sex ratio or proportion of females at age i in year j,
W_{ij} = mean weight of fish at age i in year j in tonnes.

However, some of these data are not always available so a more synoptic estimate of total biomass is calculated using the following data. The total catch is obtained from sales slip information except for the current season when validated landings estimates are used. The estimated escapement for each region is derived from information on spawn deposition. The estimate of total spawn deposition is also used as the spawn index in the age-structured model. Dive survey observations of egg deposition are used directly while surface survey observations are adjusted to emulate Scuba estimates. Total egg deposition is calculated as the product of: total length parallel to the shore of each spawning bed; the observed or adjusted width of the spawning bed; and egg density as estimated from the average number of egg layers determined from the surface survey, or average predicted egg density from quadrat observations of egg layers, or average egg layer and plant density estimates in giant kelp (*Macrocystis* sp.) beds from Scuba surveys. Total egg deposition estimates for all spawning beds are summed within each assessment region and the total egg deposition is converted to tonnes of spawning fish based on an estimate of 100 eggs per gram of herring on average (Hay 1985) as described above.

Surface Surveys

Since the late 1920s there have been organized efforts to assess the amount of herring eggs deposited throughout the British Columbia coast as an indicator of stock abundance. The parameters which have been monitored consistently are total length of each spawning bed measured parallel to the shoreline, the average width of each spawning bed, and an estimate of intensity of the spawn deposition. Prior to 1981, intensity was estimated subjectively on either a 1-5 or 1-9 scale of light to heavy (Hay and Kronlund 1987). Subsequently, intensity of egg deposition was recorded as the number of egg layers observed on each of several types of algal substrate. Beginning in 1987, an increasing proportion of the spawning beds have been surveyed using Scuba techniques as outlined below.

To provide a consistent coastwide assessment of total egg deposition throughout the time period from 1951-1999, it was necessary to intercalibrate the surface and Scuba surveys of egg deposition. Initially, the intercalibration took the form of linear equations which converted the surface survey estimates of spawning bed width and egg layers to comparable Scuba estimates (Schweigert and Stocker 1988). However, the data available for this intercalibration were limited in time and space to particular spawning beds over the course of a few years. As Scuba surveys of the spawning beds became widespread, an extensive database of estimates of the dimensions of herring spawning beds in most areas of the coast became available and a new procedure for calibrating the width of herring spawning beds estimated by surface surveys was proposed (Schweigert et al. 1993). The methodology consisted of defining spawn pools which consisted of one or more geographically adjacent and geomorphologically similar herring spawning locations. Hence, diver width estimates developed for such a 'pool' were felt to be characteristic of all locations within that pool. For the small number of locations which could not be assigned to a pool, the median width for the section (Haist and Rosenfeld 1988) was used to adjust width estimates for the location. The median width was preferable to the mean because of the non-normal distribution of the spawn width estimates. Any pools for which fewer than 25 observations of median width existed were also adjusted using the section median. For the rare instances where no median estimate was available at the section level the median width for the assessment region was applied to calculate spawn area. The long term median spawn width for each pool was then applied to each surface survey record to estimate a 'diver' width and combined with the estimated surface length to determine the total area of egg deposition.

To estimate egg density we assumed that surface and dive survey estimates of the number of egg layers in a spawning bed were equivalent and employed the database of 5111 observations of egg density per square meter from laboratory egg counts of Scuba surveyed quadrat samples to develop a predictive model of egg density from egg layers:

$$Eggs / m^2 = 14.698 + 212.218\ Layers$$

The relationship is statistically significant ($P<0.001$). Total egg deposition for each egg bed is then estimated from the product of total spawning bed area, and egg density predicted from the average surface egg layer estimate.

At present, no methods exist for adjusting surface survey data in most areas outside the major assessment regions except in a few locations such as Johnstone Strait (Statistical Areas 9-13) where some dive surveys have been conducted. These surveys indicated that no adjustments are required for the spawn widths in Johnstone Strait because widths are very narrow and were accurately assessed from the surface in this area (Schweigert and Haegele 1988a, b). Additional dive surveys still need to be conducted in other areas outside of the major assessment regions to develop width adjustments for the spawn pools in these locations.

Scuba Surveys

For Scuba surveys spawning bed lengths are determined by exploratory raking or snorkelling to define the limits of the areas of egg deposition. A systematic sampling regime is employed whereby transects are set across the egg bed perpendicular to shore at 350 m intervals. Corresponding spawning bed widths are estimated as the mean of all transect lengths within the spawning bed. Estimates of mean egg density are based on a two-stage sampling design (Schweigert et al. 1985, 1990). Average egg density for each spawning area is estimated as the weighted mean of the means of a series of quadrats located along each transect. For each quadrat, observations are made on several variables: type of algal substrate; proportion of the quadrat covered by each algal type; number of layers of eggs on each algal type; proportion of the bottom substrate covered by eggs; and an estimate of the number of egg layers on the bottom substrate. In some areas, assessments are also made of the egg deposition on the giant kelp as described in a following section.

Egg deposition for each sampling quadrat is estimated from the predictive equation described in the 1989 assessment (Haist and Schweigert 1990, Schweigert 1993). Egg density for each vegetation subfraction is estimated as follows:

$$Eggs_{ij} = 1033.6694\, L_{ij}^{0.7137}\, P_{ij}^{1.5076}\, V_{ij}\, Q_j.$$

where

$Eggs_{ij}$ = estimated number of eggs in thousands per m^2 on vegetation type i in quadrat j,
L_{ij} = number of layers of eggs on algal substrate i in quadrat j,
P_{ij} = proportion of quadrat covered by algal substrate i in quadrat j,
V_{1j} = 0.9948 parameter for sea grasses in quadrat j,
V_{2j} = 1.2305 parameter for rockweed in quadrat j,
V_{3j} = 0.8378 parameter for flat kelp in quadrat j,
V_{4j} = 1.1583 parameter for other brown algae in quadrat j,
V_{5j} = 0.9824 parameter for leafy red and green algae in quadrat j,
V_{6j} = 1.0000 parameter for stringy red algae in quadrat j,
Q_1 = 0.5668 parameter for 1.00 m^2 quadrats,
Q_2 = 0.5020 parameter for 0.50 m^2 quadrats,
Q_3 = 1.0000 parameter for 0.25 m^2 quadrats.

Total egg density (thousands of eggs per m^2) for each quadrat is then estimated by summing the egg density estimates over the vegetation types,

$$Eggs_j = \sum_i eggs_{ij}.$$

Eggs on Bottom and *Macrocystis*

Eggs on rock are estimated from the product of the proportion of the quadrat covered by eggs, number of egg layers, and 340,000 eggs/m^2 (Haegele *et al.* 1979). Eggs on rock also includes eggs on other inorganic substrata as well as egg deposition on very short (1-2 cm) red algae, calcareous encrusting algae, worm tubes, logs, etc. Total egg density for each quadrat is the sum of eggs on vegetation plus eggs on rock.

In some northerly areas such as the Queen Charlotte Islands and the Prince Rupert District a significant proportion of the total egg deposition can occur on the giant kelp, *Macrocystis* sp., with smaller amounts in some localities on the central coast and west coast of Vancouver Island. The approach we have adopted for routine Scuba surveys follows that outlined by Haegele and Schweigert (1985). The Scuba transects which are used to assess egg density on understorey vegetation are also used to enumerate *Macrocystis* plants and fronds within 1 m on either side of the transect line. An egg prediction equation has been developed (Haegele and Schweigert 1990) to estimate egg numbers for an individual plant:

$$Eggs/Plant = 0.073\ Layers^{0.673}\ Height^{0.932}\ Fronds^{0.703}$$

where

Eggs/Plant = total number of eggs on the *Macrocystis* plant in millions,
Layers = average number of egg layers on each *Macrocystis* plant,
Height = total height of the *Macrocystis* plant in metres,
Fronds = total number of fronds per *Macrocystis* plant.

This equation estimates the number of eggs occurring on a plant of a specific height with a certain number of fronds and egg layers. In practice, the synoptic Scuba survey estimates only the average number of egg layers per plant, the average plant height, and the average number of fronds per plant along each transect. These quantities are used in the above equation to estimate the total egg numbers per plant for each transect. These estimates are averaged across transects to obtain an average number of eggs per plant for the entire *Macrocystis* bed.

This information may then be combined with the estimate of the density of plants and the estimated area of the *Macrocystis* bed to obtain an estimate of the total number of eggs deposited on the kelp:

$$Total\ Eggs\ on\ Macrocystis = Eggs\ Plant^{-1} \bullet Plants\ m^{-2}$$

This egg deposition is then added to the estimated eggs on the understorey vegetation to determine a total egg deposition for that spawn pool.

Enumerated Egg Samples

Beginning in 1988 samples of algae and the attached eggs from entire quadrats were collected and processed to evaluate model predictions of egg density relative to sample egg counts. Due to funding shortfalls, no samples have been collected since 1997 and model predictions of egg numbers per sample quadrat are assumed to be unbiased for use in the assessment of egg density.

Abundance Forecasts and Survival Estimates

The escapement model forecasts abundance of returning adult spawners by applying an apparent survival rate to the estimate of spawning escapement in the most recent year. Mean age-specific apparent survival rates were introduced in 1991 to adjust for apparent under-forecasting of returning adults based on their abundance in the previous year's escapement due to partial recruitment of younger age-classes and other factors.

Several estimates of the instantaneous natural mortality rate are available for British Columbia herring. Tester (1955) estimated the age-specific mortality for the Strait of Georgia (0.45 to 0.79) and west coast of Vancouver Island (0.43 to 1.14) for ages 3^+ to 6^+. Taylor (1964) reported a natural mortality rate of 0.55 for ages 5^+ to 8^+ for Barkley Sound samples taken from unfished stocks. Schweigert and Hourston (1980) estimated natural mortality at 0.36 from Barkley Sound catch and effort data during 1954 to 1967 for ages 2^+ to 4^+. Since the spawning herring stocks currently consist mostly of ages 2^+ to 7^+ we used an instantaneous natural mortality of 0.45, implying an annual survival rate of 64 percent, in forecasting the number of returning adults (3^+ and older fish) prior to the 1991 assessment. Subsequently, we have used the ratio of the estimated number of returning fish at age this year relative to the estimated escapement at the previous age last year to provide an estimate of the apparent age-specific survival rate:

$$A_{ij} = \frac{E_{ij} + O_{ij}}{E_{i-1,j-1}}$$

where

A_{ij} = apparent survival of age j fish in season i,
E_{ij} = estimated number of spawning fish at age j in season i,
O_{ij} = estimated number of age j fish in the catch in season i.

Comparison of the estimated numbers of returning fish at age with the escapement estimate the previous year indicated a tendency to underestimate recruitment and led to the

adoption of the apparent survival rate (Fig. 2.1). The apparent age-specific survival rate includes not only the effect of survival, but also factors such as: biases in estimates of the spawning stock, partial recruitment of the younger age classes, and inconsistencies in the age composition data. To ensure that forecasts of stock abundance are consistent with the observed data, the geometric means of the age-specific apparent survivals for each stock assessment region were re-calculated for the entire the 1971-1999 roe period (Table 2.1) and are used to forecast 2000 abundance.

Table 2.1. Geometric mean age-specific apparent survival estimated for each stock assessment region over the roe fishery period, 1971-1999.

	Age Class				
Assessment Region	2^+-3^+	3^+-4^+	4^+-5^+	5^+-6^+	6^+-7^{++}
Queen Charlotte Is.	1.47	1.17	1.01	0.89	0.55
Prince Rupert	1.26	1.21	1.06	0.87	0.55
Central Coast	1.52	1.31	1.16	1.00	0.69
Georgia Strait	0.83	0.69	0.60	0.57	0.42
W.C. Vancouver Is.	1.05	0.85	0.80	0.74	0.47

Hence, the equation used to forecast the tonnage of herring expected to return in the coming season is:

$$B_{i+1,j+1} = N_{ij} A_{ij} W_{i+1,j}$$

where

$B_{i+1,j+1}$ = forecast tonnes of mature biomass at age $i+1$ in year $j+1$,
N_{ij} = estimated number of fish at age i in the escapement in year j,
A_{ij} = estimated apparent survival rate of fish at age i in year j,
$W_{i+1,j}$ = observed average weight at age $i+1$ in year j.

Forecasts of mature biomass for each stock assessment region based on this analysis are presented in Section 4.

2.3 RESULTS

Estimates of historical and current year stock abundance and total catch for the major stock assessment regions are presented in Tables 2.2 and 2.3. Similar estimates for the minor stocks in Areas 2W and 27 are presented in Table 2.4 and discussed in Section 4.

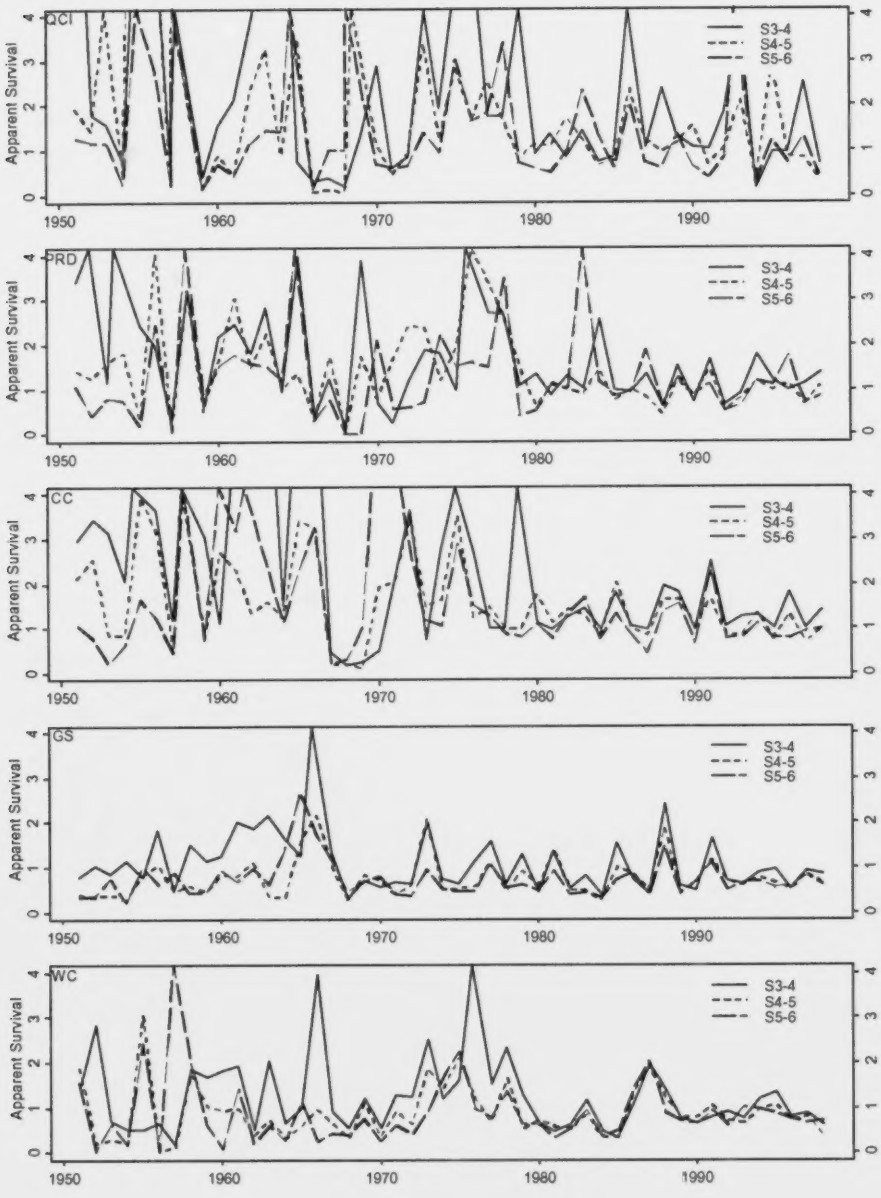

Figure 2.1. Estimates of apparent survival rate from ages 3 to 4, 4 to 5, and 5 to 6 for all assessment regions from 1951 to present.

Table 2.2. Estimates of spawning stock biomass, catch, and total pre-fishery abundance (tonnes) for the northern stock assessment regions for 1971-1999.

	Queen Charlotte Islands			Prince Rupert District			Central Coast		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock	Spawners	Catch	Stock
1970/71	13616	102	13718	9751	3500	13252	6056	3614	9670
1971/72	9951	3972	13923	9852	4494	14346	3928	9279	13207
1972/73	7706	7520	15226	11260	1607	12867	14471	7799	22270
1973/74	9903	6318	16221	8893	3819	12712	10624	8887	19511
1974/75	8951	7724	16675	11109	1702	12811	9165	8739	17903
1975/76	15143	14116	29258	14213	4307	18520	16134	12411	28545
1976/77	12516	12635	25151	9736	8142	17877	18481	11106	29587
1977/78	11452	11726	23177	4738	8588	13325	10097	14046	24143
1978/79	8657	7953	16610	7554	4317	11871	6550	5	6555
1979/80	21204	3316	24520	10236	3425	13661	15978	538	16517
1980/81	19023	5631	24654	10532	3090	13622	16949	2573	19522
1981/82	19009	3778	22788	12631	1984	14616	18412	6370	24782
1982/83	19082	5597	24679	19653	0	19653	16618	5640	22258
1983/84	20438	4647	25084	22927	3706	26633	14197	7171	21368
1984/85	14393	6109	20501	35858	6747	42605	8480	5209	13689
1985/86	5636	3503	9140	32526	8679	41205	15534	3386	18920
1986/87	13132	2061	15193	31422	6271	37693	12992	3615	16607
1987/88	14456	32	14488	33680	7968	41647	27018	4527	31544
1988/89	23986	1461	25448	12783	8474	21257	32335	9442	41776
1989/90	25011	7801	32812	19398	5505	24903	31048	8805	39853
1990/91	14220	5530	19750	21544	4326	25869	20155	9357	29512
1991/92	9500	3612	13112	35992	4992	40984	46036	8756	54792
1992/93	5405	3951	9356	21440	7717	29157	39713	11060	50773
1993/94	4895	1387	6282	13439	5413	18852	29781	12332	42113
1994/95	4946	0	4946	15858	2877	18738	18919	10308	29227
1995/96	5827	0	5827	22104	4178	26282	17941	5209	23150
1996/97	11686	0	11686	20744	6815	27559	25208	4806	30011
1997/98	18871	2100	20906	16734	4218	20952	29386	9965	39351
1998/99	9714	3792	13506	25699	3114	28813	28924	8738	37662

Table 2.3. Estimates of spawning stock biomass, catch, and pre-fishery stock abundance (tonnes) for the southern stock assessment regions from 1971-1999.

	Strait of Georgia			W.C. Vancouver Island		
Season	Spawners	Catch	Stock	Spawners	Catch	Stock
1970/71	47312	1694	49005	32476	0	32476
1971/72	25875	8811	34686	36069	6894	42963
1972/73	18257	7649	25906	16219	18303	34522
1973/74	64619	4004	68622	24774	16334	41108
1974/75	76692	6179	82871	44594	26109	70703
1975/76	57135	12238	69372	63335	38825	102160
1976/77	58003	17509	75512	57398	30043	87441
1977/78	97082	24002	121084	39931	22745	62676
1978/79	59042	20338	79380	63663	18694	82357
1979/80	74848	5818	80666	62619	3982	66601
1980/81	48230	12052	60282	58518	8090	66608
1981/82	90239	12833	103072	29424	5486	34911
1982/83	47423	17218	64641	15329	8575	23904
1983/84	27588	11045	38632	22142	6577	28719
1984/85	26629	7030	33659	29132	178	29310
1985/86	61097	594	61690	38347	204	38551
1986/87	39037	9353	48390	29915	15934	45849
1987/88	25351	8215	33566	39289	9724	49013
1988/89	54078	8369	62447	43331	13289	56620
1989/90	58912	8119	67031	38337	10121	48458
1990/91	43421	11103	54524	25907	8906	34813
1991/92	80122	13419	93541	36811	3986	40797
1992/93	84961	13741	98702	29237	5884	35122
1993/94	60862	17647	78509	19764	6310	26075
1994/95	59708	13190	72897	25039	2586	27625
1995/96	76291	14113	90404	31929	1516	33445
1996/97	53442	19809	73251	39114	7383	46497
1997/98	68669	13604	82303	36898	7363	44261
1998/99	70165	13285	83450	18829	5097	23926

Table 2.4. Estimates of spawning stock biomass, catch , and pre-fishery stock abundance (tonnes) for the minor stocks in areas 2W and 27 for 1971-1999.

	Area 2W*			Area 27		
Season	Spawners	Catch	Stock	Spawners	Catch	Stocks
1970/71	655	0	655	356	0	356
1971/72	1026	0	1026	333	0	333
1972/73	1782	706	2488	2293	0	2293
1973/74	1705	403	2109	0	526	526
1974/75	1446	449	1895	1409	0	1409
1975/76	1066	0	1066	227	79	306
1976/77	1228	0	1228	568	0	568
1977/78	1898	575	2472	3016	150	3166
1978/79	547	691	1237	6067	693	6760
1979/80	2658	0	2658	12094	519	12613
1980/81	2016	770	2786	1683	671	2354
1981/82	6348	1225	7573	3452	571	4023
1982/83	6120	2518	8638	2256	163	2419
1983/84	2552	0	2552	2520	171	2690
1984/85	1544	199	1743	1408	0	1408
1985/86	649	0	649	3772	0	3772
1986/87	757	0	757	2643	0	2643
1987/88	3202	0	3202	1518	0	1518
1988/89	3696	0	3696	3835	0	3835
1989/90	10487	2272	12759	4645	245	4890
1990/91	2789	2558	5347	3277	245	3522
1991/92	3564	1284	4848	2682	539	3221
1992/93	88	1306	1393	5216	707	5923
1993/94	193	0	193	3120	708	3828
1994/95	0	0	0	2014	542	2556
1995/96	0	0	0	1501	363	1864
1996/97	0	0	0	1598	273	1871
1997/98	372	180	552	1732	273	2005
1998/99	0	0	0	564	273	837

*- No estimates of stock biomass are available in area 2W for 1995-97 and 1999. Spawning activity was observed in the area but no surveys were conducted or surveys did not detect spawn.

3. AGE-STRUCTURED MODEL

3.1. INTRODUCTION

An age-structured model, based on the error structure suggested by Fournier and Archibald (1982), has been used to assess B.C. herring stocks since 1982. Ongoing revisions to the model have made it more consistent with the life history of herring and the fisheries which are analyzed. The current version uses auxiliary information in the form of spawning escapement data, separates catch and age composition data by gear type, and includes availability parameters to estimate partial recruitments to the spawning stock. Model parameters are estimated simultaneously using a maximum likelihood method. The model formulation used this year is the same as that used beginning with the 1994 assessment (Schweigert and Fort 1994). The model uses escapement model estimates of spawning stock biomass as the abundance or spawn index for parameter estimation. The model is implemented in the C^{++} programming language using AD model builder software (Otter Research Ltd, 1996) for derivative calculations replacing the AUTODIF version used in earlier assessments. A comparison of abundance estimates from the two implementations of the age-structured model were presented in the 1997 assessment.

3.2. METHODS

The Population Model

Two types of fishing gear are used commonly in B.C. herring fisheries. Seine nets are assumed to be non-selective while gillnets are selective for larger, older fish. Herring fisheries have concentrated primarily on fish which are on, or migrating to the spawning grounds. Therefore, the relative availability of age classes to non-selective gear should be equivalent to the partial recruitment of age classes to the spawning stock. The age-structured model explicitly separates availability (partial recruitment) and gear selectivity. Seine and gillnet fisheries are temporally separate so catch and age-composition are partitioned into fishing periods, separating data for the different gears. Three fishing periods are modelled. The first period encompasses all catch prior to the spring roe herring fisheries. This includes reduction fishery catches prior to 1968 and the winter food and bait fisheries since 1970. Most of this catch was taken by seine gear although small amounts were caught with trawl nets (which are also assumed to be non-size selective). The second fishing period includes all seine roe herring catch and the third period includes all gillnet roe herring catch.

Let T_{ij} be the total number of fish in age class j at the beginning of season i, where season is equivalent to year, and λ_{ij} be the proportion of age j fish which are available to the fishery. Then N_{ij1}, the total number of age class j fish which are available at the start of period 1 in season i is given by

$$N_{ij1} = \lambda_{ij} T_{ij}, \text{ where } 0 \langle \lambda_{ij} \langle 1 \qquad 3.1$$

To model the fishing process a form of the catch equations which models fishing and natural mortality as continuous processes over time period r, is used:

$$C_{ijr} = \frac{F_{ijr}}{F_{ijr} + M_r}\left(1 - \exp(-F_{ijr} - M_r)\right) N_{ijr},$$

and, for $r < p$

$$N_{ijr+1} = N_{ijr} \exp(-F_{ijr} - M_r),$$

where

C_{ijr}	is the catch of age class j in season i for period r,
F_{ijr}	is the fishing mortality of age class j in season i for period r,
M_r	is the natural mortality for period r,
N_{ijr}	is the number of fish in age class j in season i for period r,
p	is the number of fishing periods (p=3),
n	is the number of seasons (n=49),
k	is the number of age classes (k=9).

$N_{i+1,j+1,1}$ is defined by equation 3.1 where for $j+1 < k$

$$T_{i+1,j+1} = N_{ijp} \exp(-F_{ijp} - M_p) + T_{ij}(1 - \lambda_{ij}) \exp \sum_r - M_r \qquad 3.2$$

In the model the last age class, k, accumulates all fish aged k and older, so for $j+1=k$ equation 3.2 is replaced by

$$T_{i+1,k} = N_{i,k-1,p} \exp(-F_{i,k-1,p} - M_p) + T_{i,k-1}(1 - \lambda_{i,k-1}) \exp\left(\sum_r - M_r\right)$$

$$+ N_{ikp} \exp(-F_{ikp} - M_p) + T_{ik}(1 - \lambda_{ik}) \exp\left(\sum_r - M_r\right).$$

To reduce the number of parameters to be estimated, assumptions are made about the form of the availabilities and mortalities. The availabilities are formulated to increase with age and are set to 1 for age 6+ and older. For age 3+ to 5+ the availabilities are constant between years, that is,

$$\lambda_{ij} = \lambda^{\bullet}_{j},$$

The proportion of age 2^+ fish which are mature appears to vary among years (Haist and Stocker 1985) and some reduction fisheries targeted on immature 1^+ fish. Therefore, the availabilities for these two age classes are estimated for each year for which there is age-composition data with

the exception of the final year. In the final year the availabilities for age 1+ and 2+ fish are set equal to the average over all years in the time series.

For the selective gillnet fishery (i.e. fishing period 3), fishing mortality is separated into age selectivity and fishing intensity components. Following Doubleday (1976),

$$\ln\left(F_{ij3}\right) = \alpha_{i3} + b_j \qquad 3.2a$$

where α_{i3} represents the general level of fishing mortality due to the gillnet fishery in season i, and b_j represents the relative selectivity of the gear for age-class j. The b_j are reparameterized such that age selectivity is modelled as a function of annual average weights-at-age. A modified logistic equation is used,

$$b_{ij} = \frac{1}{1+\exp(\rho - \tau g_{ij}^{\omega})}$$

where g_{ij} is $\log_e$ of the geometric mean weight-at-age j in year i. The b_{ij} replace the b_j in equation 3.2a.

For non-selective fisheries (i.e. fishing periods 1 and 2) only fishing intensity parameters are estimated, that is

$$\ln\left(F_{ijr}\right) = a_{ir}.$$

As in last year's assessments a natural mortality parameter, M_*, is estimated. It is assumed that most of the natural mortality occurs following spawning and over the course of the summer and early winter prior to the first fishery (period 1). Little or no natural mortality is assumed during the course of the roe fisheries (periods 2 and 3) which occur over a roughly 2 week period at the end of the year. Hence, various proportions of the annual natural mortality for the three fishing periods is modelled as,

$$M_1 = 0.95M_*$$
$$M_2 = M_3 = 0.025M_*$$

Additional structure is built into the model through the inclusion of annual spawn data (spawn index, I_i). Spawning occurs at the end of the season so the number of spawners at age j in season i (G_{ij}) is estimated by

$$G_{ij} = N_{ijp} \exp\left(-F_{ijp} - M_r\right) \qquad \text{where } j>1$$

and the spawning stock biomass, which is assumed to be equivalent to egg production, in season i, (R_i) is

$$R_i = \sum_j w_{ij} G_{ij},$$

where w_{ij} is the average weight-at-age j in season i. The error in the spawn index observations (I_i) are assumed to be multiplicative so that

$$I_i = q R_i \exp(\xi_i), \qquad 3.3$$

where q is a spawn conversion factor and ξ_i is a normally distributed random variable with mean 0 and variance σ_1^2. For the model described above the parameters to be estimated are:

T_{in}, for all seasons i,
T_{ij}, for age classes 1+ to k,
λ^*_j, for age classes 3+ to 5+,
λ_{ij}, for age classes 1+ and 2+, for seasons 1 to n-1,
α_{ir}, for all fisheries I, r,
ρ, τ, ω, M, and q.

The λ^*_j and λ_{ij} are parameterized to constrain their values between 0 and 1. The parameter σ_1^2 is not estimated in the reconstructions, but is fixed as discussed later on.

The Objective Function

Data input to the stock reconstruction are:

S_{ijr}, the number of sampled fish aged j in season i for period r,
O_{ir}, the estimated number of fish caught in period r of season i,
I_i, the estimated escapement biomass or spawn index in season i,
w_{ij}, the mean weight-at-age j in season i,
g_{ij}, the $\log_e$ of the geometric mean weight-at-age j in season i.

The error structure suggested by Fournier and Archibald (1982) for the observations S_{ijr} and O_{ir} is used:

1) the S_{ijr} are obtained from ageing random samples of fish from the catch (and there are no ageing errors, i.e. a multinominal sampling distribution).

2) the error structure for the estimated number of fish caught (O_{ir}) is log-normal. That is,

$$O_{ir} = C_{ir} \exp(\xi_i),$$

where C_{ir} is the actual number of fish caught in period j in season i ($C_{ir} = \sum_j C_{ijr}$) and the ξ are independent normally distributed random variables with mean 0 and variance σ_3^2.

3) the random variables S_{ijr} and O_{ir} are independent.

Given these stochastic assumptions, the log-likelihood function (ignoring the constant term), for the parameters P_{ijr} $(P_{ijr} = C_{ijr} / C_{ir}), C_{ir}$, and σ_3^2 is

$$\sum_{ijr} S_{ijr} \ln(P_{ijr}) - \sum_{ir} \frac{(\ln(O_{ir}) - \ln(C_{ir}))^2}{2\sigma_3^2} \qquad 3.5$$

The assumption of log-normal measurement error in the observed spawn-actual spawn relationship introduces the following contribution to the log-likelihood function:

$$-\sum_i \frac{(\ln(I_i) - \ln(q R_i))^2}{2\sigma_1^2} \qquad 3.6$$

The w_{ij} and g_{ij} are assumed to be estimated without error.

The objective function described above (eqn. 3.5 & 3.6) incorporates measurement error in the proportion at age data, the total catch data and the spawn index data, with the relative magnitude of the errors related through the variance terms σ_1^2, σ_3^2, and the sample sizes $\sum_r S_{ijr}$. Because there is not enough information in the data to estimate the relative error in these observations, with the exception of scaling the S_{ijr}, the variance terms are not estimated but are held at fixed values. The following variances are assumed:

$$\sigma_1^2 = 0.05,$$
$$\sigma_3^2 = 0.0025,$$

These correspond to approximately a 4% average error in estimating the total number of fish caught and an 18% average error in spawn index observations.

The actual number of fish aged could be used in the objective function, however, this may not give a realistic estimate of the precision of the proportion-at-age data. That is, the biological samples obtained may not reflect a homogeneous population. The among-load (i.e. samples from different catching vessels) variability in age composition is significantly different among years, and this is related more to the spatial and temporal distribution of the fisheries than

to the number of loads sampled or total fish aged. Therefore, the information in the subsamples (between load samples), which are pooled to obtain an estimate of the age composition for a given fishery, is used to scale the S_{ijr}.

The theoretical variance of the observed proportion of fish at age j ($\hat{p}_j$) for a random sample of size S is:

$$\sigma^2_{\hat{p}_j} = \frac{p_j\left(1 - p_j\right)}{S}$$

where p_j is the true proportion at age j. An estimate of the variance of $\hat{p}_j$ is:

$$s^2_{\hat{p}_j} = \frac{\sum_k \left(p_{jk} - \hat{p}_j\right)^2}{K\text{-}1}$$

where p_{jk} is the proportion at age j in sub-sample k and K is the number of subsamples. This among sub-sample variance results from the variance generated by randomly sampling an individual catch plus the variance in the true proportion at age among vessel catches. Using $\hat{p}_j$ as the best estimate for p_j the theoretical sample size (S') which would generate the observed variance at age j is:

$$S' = \frac{\hat{p}_j\left(1 - \hat{p}_j\right)}{s^2_{\hat{p}_j}}$$

These theoretical sample sizes, calculated from the among sample variance of age 3+ fish (Appendix Table 1), are used in the objective function.

To facilitate an assessment of the lack of model fit to the age composition data the standard deviates of the observed versus predicted proportions-at-age (Z_{ijr}) are calculated:

$$Z_{ijr} = \frac{S_{ijr} - \left(\sum_r S_{ijr}\right) P_{ijr}}{\sqrt{S_{ijr}\left(1 - \frac{S_{ijr}}{\sum_r S_{ijr}}\right)}}$$

The contribution to the objective function from the lack of fit for the age composition data for a fishery in period r in season i is:

$$V_{ir} = \sum_r S_{ijr} \ln P_{ijr} - \sum_r S_{ijr} \ln \left(\frac{S_{ijr}}{\sum_r S_{ijr}} \right)$$

The second term in this equation is a constant. Inclusion of this term allows comparison of the contribution to the lack of fit for the age composition data for each fishery. If the predicted and observed proportion at age data were identical, the V_{ir} would be zero.

Stock Forecasts

Forecasts of stock abundance for 2000 are calculated by assuming all natural mortality for the first period will occur prior to the fisheries. The numbers of fish at age prior to the fisheries are then the numbers estimated at the beginning of the 1999/00 season multiplied by survival for the first period and the estimated availability at age. Recruitment is calculated for three scenarios based on estimated numbers-at-age 2^+ for the 1951-99 time series. Poor, average, and good recruitment are calculated as the mean of the lowest 33%, the mid 33%, and the highest 33% of historic age 2^+ numbers.

Input data used for age-structured model analysis are shown in Appendix Tables 1.1 to 1.5 for all stock groupings. Where no sample data are available, but catches were taken, the catch is included with an alternate fishery where age-structure data are available. Beginning with the 1994 assessment the estimate of total egg deposition as determined by the escapement model is used as the spawn index. Estimates of numbers of fish at age from the age-structured model are presented in Appendix Tables 2.1 to 2.5 for all stock groupings.

4. STOCK TRENDS, FORECASTS AND POTENTIAL CATCH

4.1 STOCK TRENDS

Estimates of pre-fishery stock biomass over the period 1951 to 1999 from the age-structured (ASM) and escapement (ESM) models are shown in Figures 4.1 and 4.2 for the five major coastal regions and for Area 27.

For the Queen Charlotte Islands region the two models indicate similar trends in stock biomass. However, the age-structured model suggests much higher peaks in abundance in the mid 1970s and the early 1980s resulting from good recruitment of the 1971, 1972 and 1977 year-classes. Both models suggest a decrease in abundance from 1990 through 1995 with increasing abundance subsequently although the ESM suggests a slight decrease in 1999. The 1993, 1994, and 1995 year classes all appear to be of average or above average abundance. The recruiting 1996 year-class of age 2^+ fish is very poor accounting for only 2.2% of the run while the 1995 and 1994 year-classes account for 65 and 17% of the spawning run, respectively. The estimates of 1999 mature biomass are 44,200 and 13,500 tonnes from age-structured and

escapement model analyses, respectively:

Estimates of 1999 stock abundance for the Prince Rupert District assessment region are more consistent for the two models than in recent assessments (Fig. 4.1). Both models indicate a decline in abundance from 1992 through 1995 with an upward trend since then. The estimate of 1999 mature biomass is 46,500 tonnes from the ASM and 28,800 tonnes from the ESM, respectively. The dominant 1995 year-class comprises 41% of the stock. The 1994 and 1993 year-classes represent 20% and 25% of the run while the recruiting 1996 year-class accounted for only 6% of the spawning biomass.

Estimates of pre-fishery biomass for the Central Coast assessment region are very similar for the two models (Fig. 4.1). Both models indicate significant increases in abundance since 1996. The predominant 1995 year-class of age 3^+ fish comprised 43% of the stock while the 1994 year-class accounted for 34% of the spawning run and the recruiting 1996 year-class another 9%. The 1999 mature biomass estimates are from the ASM is 41,700 and from the ESM 37,700, respectively.

For the Strait of Georgia assessment region the pre-fishery stock trends estimated by the two models are similar, with the ESM suggesting more erratic fluctuations in abundance (Fig. 4.2). However, both models indicate a slight to moderate decline from the 1993 recent high abundance level. The 1995 year-class is predominant, contributing 41% of the stock while the 1994 year-class constituted 19% of the run. The recruiting 1996 year-class contributed another 25% of the total run. The ASM estimate of pre-fishery abundance in 1999 is 66,000 tonnes while the ESM estimate is 83,400 tonnes.

The pre-fishery biomass estimates for the west coast of Vancouver Island stock follow similar trends since the mid 1970s (Fig. 4.2). Both models indicate a long-term decline in abundance since 1989 with both models indicating a recent recovery through 1997 followed by declines the past two years. The 1994 year-class remains predominant in this stock comprising 39% of the run with the 1995 year-class adding 24% of the total run. The recruiting 1996 year-class accounts for 23% of the 1999 spawning run. The ESM estimate of 1999 mature biomass is 23,900 tonnes while the ASM estimate is 24,100 tonnes.

Mature biomass estimates for Area 27 stocks were available only from the ESM and indicated that 837 tonnes returned to this area during 1999. Although abundance estimates are erratic it appears that abundance has declined since 1993 (Fig. 4.2). The 1994 and 1995 year-class comprised 28 and 27% of the run respectively. The recruiting 1996 year-class accounted for another 33% of the total run.

In 1999, no surveys of spawn deposition occurred in Area 2W although some tonnages were sounded throughout the area. The biological samples from the area indicated an abundance of young fish of ages 1+ though 4+ fish. The predominant year-class was the recruiting 1996 constituting 32% of the run while the 1995 and 1994 year-classes added 28 and 14%, respectively. The pre-recruit 1997 year-class contributed 16% to the total and appears to be abundant.

4.2 STOCK FORECASTS AND POTENTIAL CATCH

Management Considerations

PSARC has reviewed the biological basis for target exploitation rate, considering both the priority of assuring conservation of the resource and allowing sustainable harvesting opportunities (Schweigert and Ware 1995). The review concluded that 20% is an appropriate exploitation rate for those stocks that are well above Cutoff or minimum spawning biomass threshold levels (PSARC 1995). The 20% harvest rate is based on an analysis of stock dynamics which indicates this level will stabilize both catch and spawning biomass while foregoing minimum yield over the long term (Hall et al. 1988, Zheng et al. 1993). A fixed escapement policy would theoretically produce higher yields and spawning stock stability but is not attainable at the operational level. For those stocks which are marginally above Cutoff we recommend the following reduced catch level:

Catch = Forecast Run - Cutoff.

This will provide for smaller fisheries in areas where the 20% harvest rate would bring the escapement down to levels below the Cutoff.

As described in the 1995 report, a bootstrap procedure was used to annually re-evaluate Cutoff levels for each major assessment region beginning in 1993/94. The bootstrap procedure relies on the recruitment estimates from the age-structured model (N_{it}), to forecast recruitment and assumes the natural mortality rate estimated by the age-structured model for each area in the population simulations (Efron and Gong 1983). The average of 100 estimates of the mean of 200 years of simulated stock sizes was taken as the measure of the equilibrium unfished biomass. Cutoff levels were established at one-fourth the unfished average biomass. However, in 1995 the Subcommittee recommended that a fixed Cutoff level should be established for each stock based on the long-term production characteristics in relation to current environmental conditions and that this Cutoff level need not be re-evaluated on an annual basis. As a result, the Subcommittee fixed Cutoff at 1994/95 levels until the analyses of individual stock productivities could be completed. These Cutoff levels for the five major stocks are:

	1992/93 Cutoff[a]	1994/95 Cutoff	1996/97 Cutoff	**1999/00 Cutoff[c]**
Queen Charlotte Islands	11700	10700	10700	**10700**
Prince Rupert District[b]	12100	12100	12100	**12100**
Central Coast	10600	18800	17600	**17600**
Strait of Georgia	22100	21200	21200	**21200**
W.C. Vancouver Island	20300	18800	18800	**18800**

[a] - Cutoff level based on simulation model with stock-recruitment relationship, and two assessment areas on the WCVI.

[b] - Because of the poor performance of the age-structured model in this region in the past the Cutoff has not been recalculated using the bootstrap approach but is based on a stock-recruitment relationship.

[c] – A Cutoff of 14,000 tonnes was proposed for the Central Coast in 1998. Uncertainty about ASM performance in 1998 resulted in retention of the existing Cutoff.

In contrast to recent practice we do not provide a weighted forecast based on the two assessment models. Instead, we provide two independent forecasts of abundance for each assessment region for consideration by the review committee (Table 4.1).

Abundance Forecasts and Potential Catches

An accurate forecast of abundance for herring requires good estimates of the numbers of returning adults, growth rate of each age group over the year, and an estimate of upcoming recruitment. Prior to the 1990 assessment, the observed weight-at-age from the previous season was used as the best forecast of the weight-at-age for the coming year. Since 1990, forecast weights-at-age from a predictive equation were used in forecasting the mature biomass for the next season. Analyses conducted during 1998 indicate that weight-at-age has been declining for several years and that the equations used to forecast weights for the coming year were inflated (Tanasichuk and Schweigert 1998). As a result, the current assessment has reverted to using observed weights-at-age from the previous season as the best forecast of weight-at-age for the upcoming year. Figures 4.3 and 4.4 present cumulative probability distributions of forecast abundances for the age-structured and escapement models. These figures represent plots of the expected run size in the coming year given the escapement last year, average growth and survival of this adult biomass and the addition of each of the historically observed recruiting year-classes to the projected adult biomass. In addition, Fig. 4.5 and 4.6 present the age-structured or escapement model estimates of historical recruitment of three year old fish to the spawning runs in each assessment region.

The forecast run size to the Queen Charlotte Islands in 2000 is 40,460 tonnes from the ASM and 15,080 tonnes from the ESM assuming average recruitment (Table 4.1). This is similar to the 1999 forecast from the ASM but represents a significant decrease from the ESM although in both cases the stock remains well above the Cutoff level. Harvestable surpluses of 8,090 or 3,020 tonnes are available in this area for 2000 based on the ASM and ESM forecasts, respectively (Table 4.2). Indications are that the 1993-1995 year-classes are average or above average contributing to the increase in abundance although the recruiting 1996 year-class appears poor (Fig. 4.5). The cumulative probability plots indicate that there is 0% probability of the 2000 run being below Cutoff based on the forecasts from either assessment model (Fig. 4.3). There are no indications of lack of model fit for residuals from either the fit to the spawn index data or age-structure data during the last few years (Appendix Table 2.1, Fig. 4.7-4.9).

The revised ASM assessment for the Prince Rupert District provides estimates of abundance which are more consistent with ESM estimates than recent assessments for this stock. There are no indications of serious lack of fit to the spawn index data in recent years (Appendix Table 2.2) and there are no large residuals from the fit to the proportion-at-age data for the seine or gillnet fishery recently although there still appear to be problems with the data from the 1970s (Fig. 4.8). The forecast run size of 41,370 tonnes based on the ASM agrees well with the 37,000 tonnes forecast by the ESM (Table 4.1). Assuming an average recruitment level, a harvestable surplus of 8,270 tonnes (ASM) or 7,400 tonnes (ESM) should be available for the Prince Rupert District in 2000 (Table 4.2). The 1993 and 1995 year-class appear to be above average while the

1994 year-class is average (Fig. 4.5). The recruiting 1996 year-class is poor. The projected stock abundances indicate that there is zero probability that the 2000 run will be less than the Cutoff level (Fig. 4.3).

The forecast for the Central coast in 2000 with average recruitment is 37,870 tonnes based on the ASM and 47,040 tonnes based on the ESM, levels comparable to the 1999 forecast (Table 4.1). The 1993 year-class was average but the recruiting 1994 and 1995 year-classes are both above average while the recruiting 1996 year-class appears poor (Fig. 4.5). The cumulative probability plots indicate that there is zero probability that the 2000 run will be below the Cutoff level (Fig. 4.3). Based on the forecast run sizes a harvestable surplus of 7,570 tonnes (ASM) or 9,410 tonnes (ESM) should be available assuming average recruitment (Table 4.2). The spawn index data fit the model well in recent years (Appendix Table 2.3) and there are no indications of lack of fit to the catch at age data (Fig. 4.9).

The forecast run size to the Strait of Georgia in 2000 is 58,890 tonnes for the ASM and 84,720 tonnes (ESM) assuming average recruitment, levels similar to 1999 (Table 4.1). The 1993 year-class appears to be average while the 1994 and 1995 year-classes are above average (Fig. 4.6). The recruiting 1996 year-class appears poor. The projected stock abundances indicate that this stock remains well above the Cutoff level (Fig. 4.4). The projected abundances suggest a harvestable surplus of 11,780 tonnes (ASM) or 16,940 tonnes (ESM) (Table 4.2). There are no indications of lack of fit to either the spawn index data (Appendix Table 2.4) or proportion-at-age data (Fig. 4.10) although the fall food and bait fishery shows some moderate residuals in recent years. Since this fall fishery represents only a small proportion of the total annual catch this should not substantially affect the assessment results.

The run forecast to the west coast of Vancouver Island assessment region in 2000, assuming an average recruitment, is 23,760 tonnes based on the ASM and 29,910 tonnes based on the ESM, which is moderately less than the forecast for 1999 (Table 4.1). While the 1994 year-class was above average the 1995 year-class is poor to average and the recruiting 1996 year-class poor. The stock biomass projections for 2000 indicate that there is about a 10% probability of the run being below Cutoff based on the ASM (Fig. 4.4). An average recruitment assumption for this stock yields a harvestable surplus of 4,750 tonnes (ASM) bringing the stock to the Cutoff level while the ESM harvestable surplus is 5,980 tonnes leaving the stock well above Cutoff (Table 4.2). The age-structure model fits the spawn index data very well in recent years (Appendix Table 2.5) and there are no significant residuals from the fit to the catch-at-age data in recent years except for the 1994 gillnet data (Fig. 4.11).

There is no forecast run size available for the minor stocks in Area 27. However, based on recent policy for this area the estimated pre-fishery biomass of 837 tonnes permits a harvest of no more than 10% of the 1999 biomass in 2000. This suggests a maximum potential harvest of 84 tonnes for the area. Estimates of recent recruitments indicates poor 1992 and 1993 year-classes followed by above average 1994 and 1995 year-classes which could result in future increase in abundance (Fig. 4.2, 4.6). However, the 1996 year-class also appears to be poor.

Profile Likelihoods

The herring age-structured model was recently converted to the AD model builder software package which provides a useful feature to investigate variation in any model parameters using Bayesian inference. In this case, it is possible to evaluate the posterior distribution of the forecast stock biomass from the age-structured model. In this analysis, model forecasts of pre-fishery biomass are calculated differently than shown in Table 4.1 where three levels of recruitment are added to the estimate of returning adult abundance. In determining the forecast biomass for the profile likelihood analysis, the estimate of numbers of fish at ages 2-9 in 1999 is projected ahead to ages 3-10 in 2000 assuming the average natural mortality rate, average availability, and current weight-at-age to estimate mature stock biomass. The estimated probability distributions of forecast 2000 biomass for the five assessment regions are presented in Figures 4.12 and 4.13.

In the Queen Charlotte Islands the profile likelihood agrees very well with the ASM forecast and indicates that abundance in 2000 is almost certainly well above that projected by the ESM. Indications are that abundance will most likely be 38,970 tonnes with a 95% probability that abundance will be greater than 28,926 tonnes.

In the Prince Rupert District the profile likelihoods correspond well with the forecasts from both the ASM and ESM. The most likely forecast is 37,048 tonnes with a 95% probability that abundance will exceed 30,734 tonnes.

In the Central Coast the profile likelihood is slightly lower than projected by either the ASM or ESM suggesting that expected recruitment may be poorer than average. The most probable forecast biomass for this stock is 33,140 tonnes with a 95% probability that biomass will exceed 25,166 tonnes.

The profile likelihood for the Strait of Georgia also indicates a forecast abundance lower than projected by either assessment model. The most likely biomass level is 51,354 tonnes with an 95% probability that abundance will be greater than 41,383 tonnes.

Finally, the profile likelihood for the west coast of Vancouver Island indicates a most likely projected biomass of 16,431 tonnes with a 95% probability that 2000 run size will exceed 13,065 tonnes. It should be noted that retrospective analyses for the two southern stocks have consistently indicated a tendency to underestimate current abundance levels suggesting that for both the Strait of Georgia and west coast of Vancouver Island stocks that these forecasts should be considered as being very conservative.

Table 4.1. Summary of 2000 forecast spawning stock biomass (thousands of tonnes) from age-structured and escapement models and weighted runs for poor, average, and good age 2^+ recruitment levels.

	AGE-STRUCTURED MODEL				ESCAPEMENT MODEL			
	Age 3^+	Age 2^+ Recruitment			Age 3^+	Age 2^+ Recruitment		
Assessment Regions	And older	Poor	Avg	Good	And older	Poor	Avg	Good
Queen Charlotte Islands	37.05	37.90	40.46	47.74	12.58	13.06	15.08	20.44
Prince Rupert District	35.96	37.75	41.37	53.95	32.24	33.56	37.00	47.51
Central Coast	34.05	35.54	37.87	45.29	42.36	43.94	47.04	58.43
Strait of Georgia	38.12	46.88	58.89	73.10	57.82	68.18	84.72	106.81
W.C. Vancouver Island	15.77	19.23	23.76	38.32	18.85	23.33	29.91	44.60

Table 4.2. Summary of 2000 Cutoff levels and forecast harvest surpluses given poor, average, and good age 2^{+} recruitment for each of the assessment regions based on the ASM and ESM.

		Abundance Forecast			Cutoff	Potential Harvest		
Assessment Regions	Model	Poor	Avg	Good	Level	Poor	Avg	Good
Queen Charlotte Islands	ASM	37.90	40.46	47.74	10.70	7.58	8.09	9.55
	ESM	13.06	15.08	20.44	10.70	2.61	3.02	4.09
Prince Rupert District	ASM	37.75	41.37	53.95	12.10	7.55	8.27	10.79
	ESM	33.56	37.00	47.51	12.10	6.71	7.40	9.50
Central Coast	ASM	35.54	37.87	45.29	17.60	7.11	7.57	9.06
	ESM	43.94	47.04	58.43	17.60	8.79	9.41	11.69
Strait of Georgia	ASM	46.88	58.89	73.10	21.20	9.38	11.78	14.62
	ESM	68.18	84.72	106.81	21.20	13.64	16.94	21.36
W.C. Vancouver Island	ASM	19.23	23.76	38.32	18.80	0.43*	4.75	7.66
	ESM	23.33	29.91	44.60	18.80	4.53*	5.98	8.92

* Harvest rate is the forecast-Cutoff to maintain stock at Cutoff level.

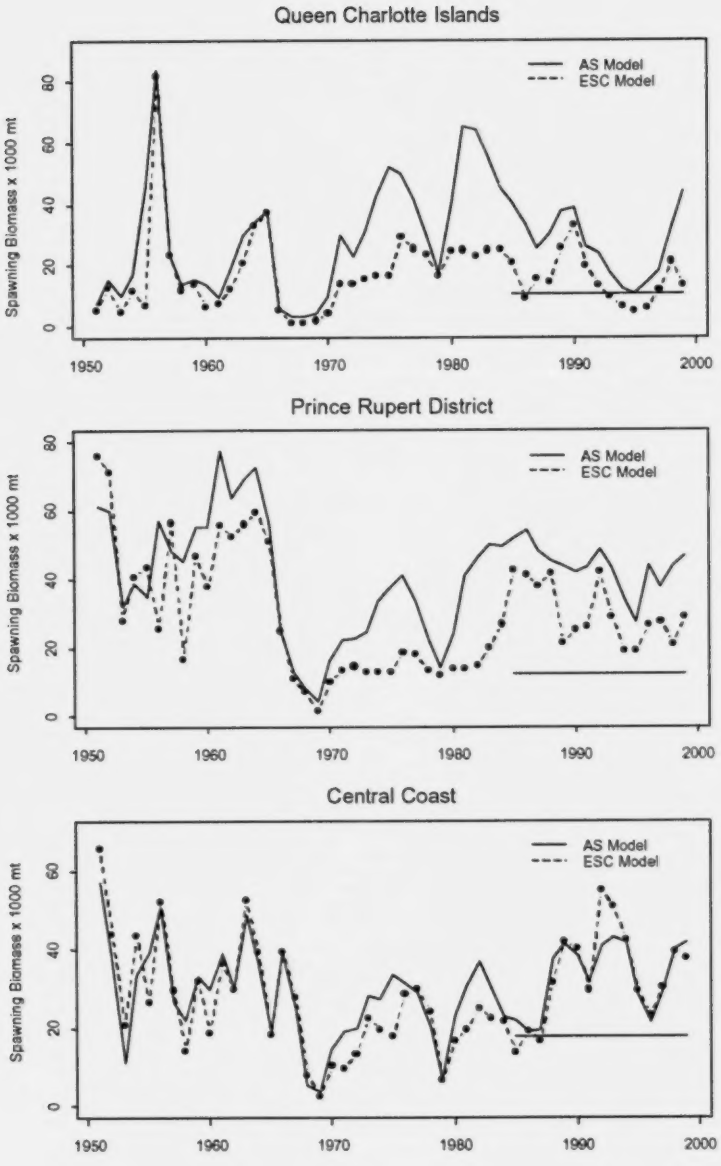

Fig. 4.1 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for northern B.C. herring stock assessment regions, 1951-1999. Horizontal line indicates the Cutoff level for each stock.

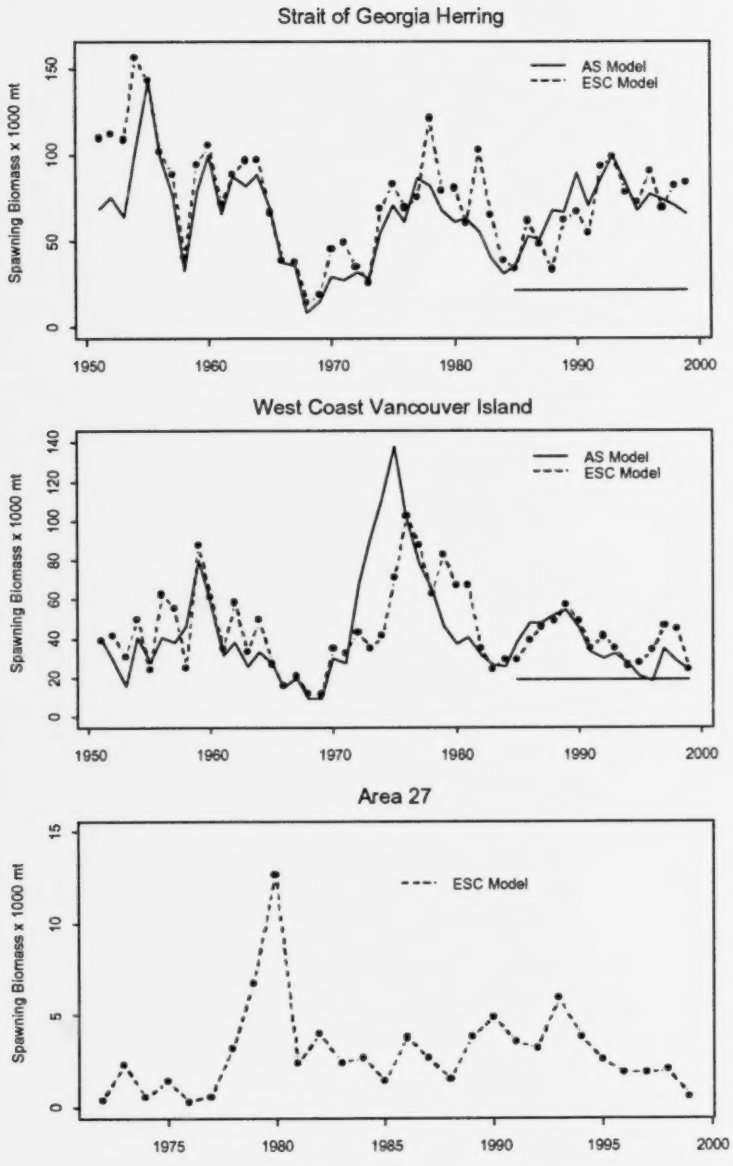

Fig. 4.2 Estimates of pre-fishery spawning stock biomass (tonnes x 1000) from age-structured and escapement model analyses for southern B.C. herring stock assessment regions and Area 27, 1951-1999. Horizontal line indicates the Cutoff level for each stock.

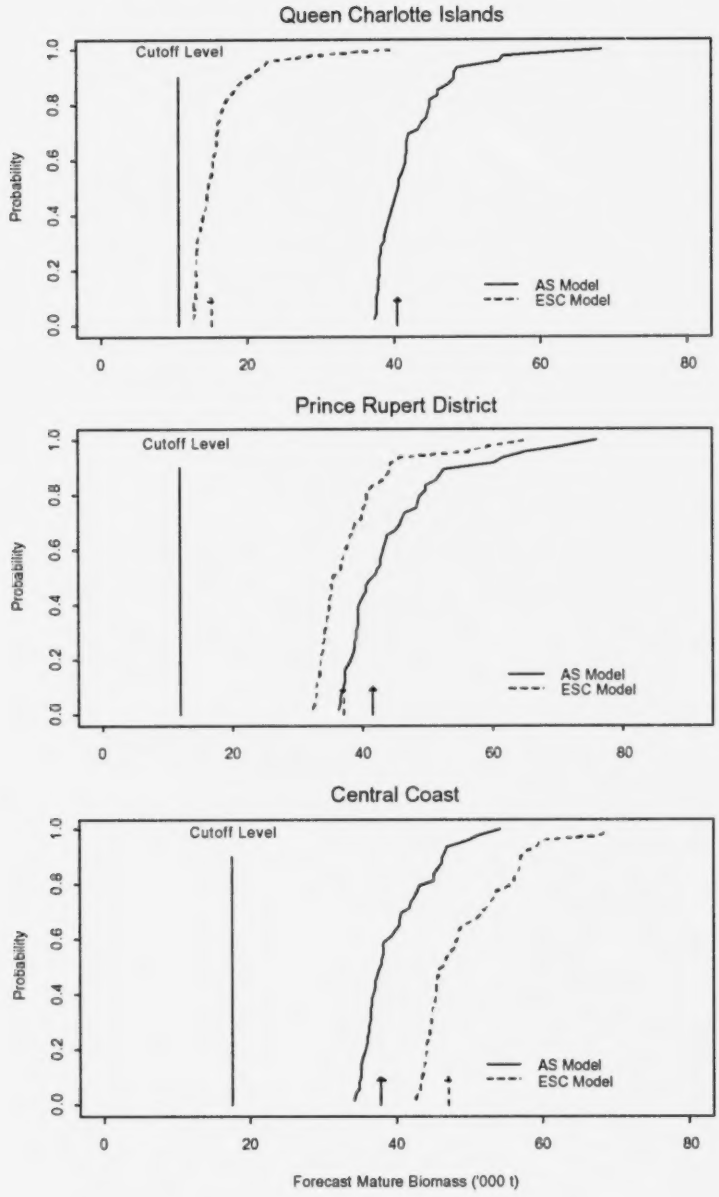

Fig. 4.3. Cumulative probability distributions of forecast spawning biomass for northern B.C. herring stock assessment regions in 2000. Arrows represent forecasts assuming average recruitment.

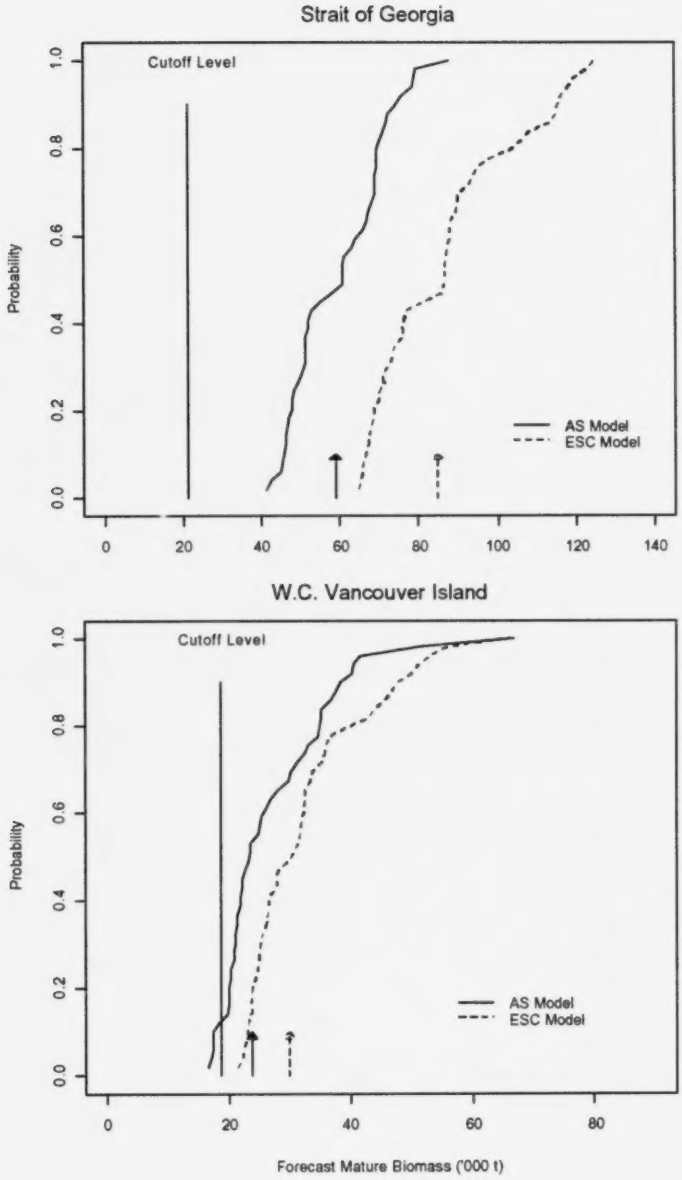

Fig. 4.4. Cumulative probability distributions of forecast spawning biomass for southern B.C. herring stock assessment regions in 2000. Arrows represent forecasts assuming average recruitment.

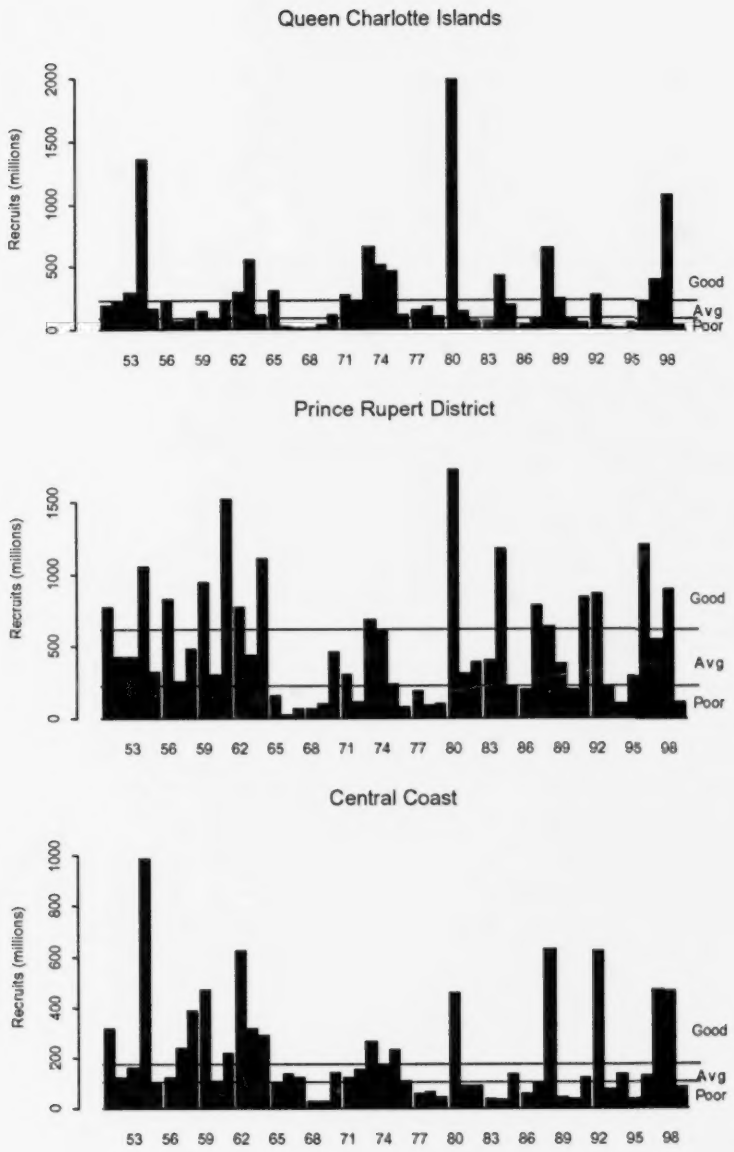

Fig. 4.5. Estimates of abundance of recruiting age 2^{+} year-classes from age-structured analysis for northern B.C. herring stock assessment regions, 1951-1999. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution.

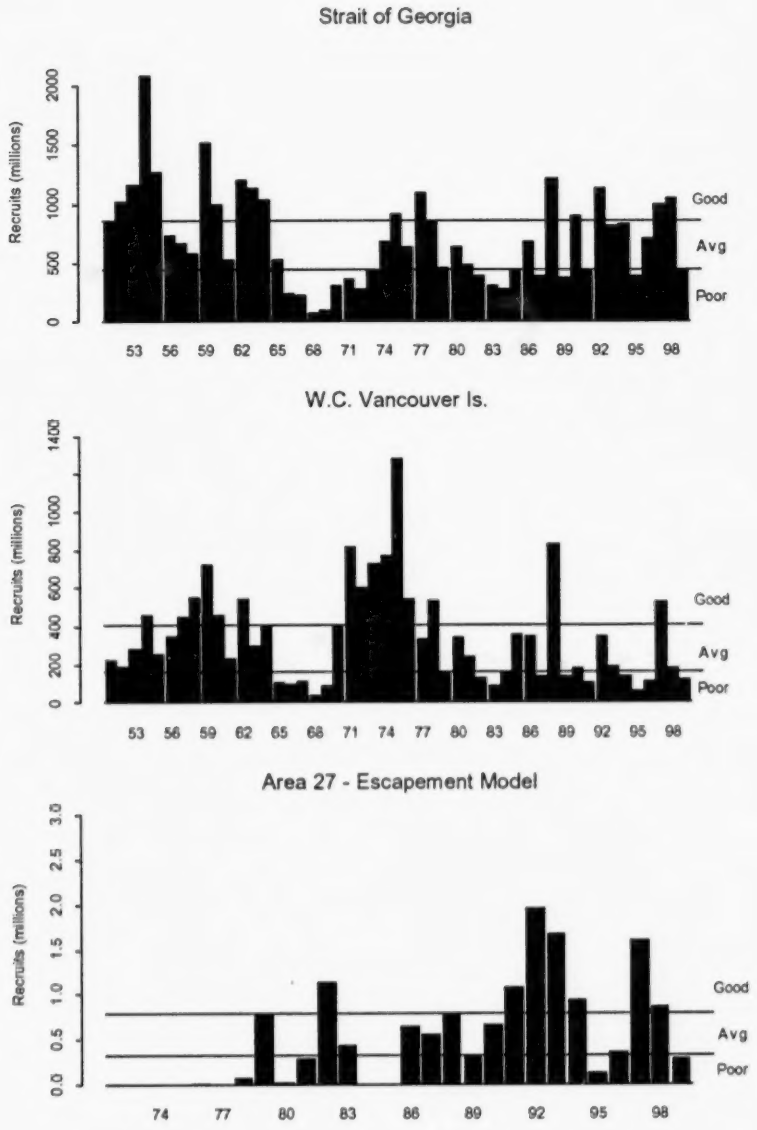

Fig. 4.6. Estimates of abundance of recruiting age 2^{+} year-classes from age-structured analysis for southern B.C. herring stock assessment regions, 1951-1999 and for the minor stock in area 27 for 1972-1999. The horizontal lines delimit poor, average, and good recruitment categories and are the 33 and 66 percentiles of the cumulative frequency distribution.

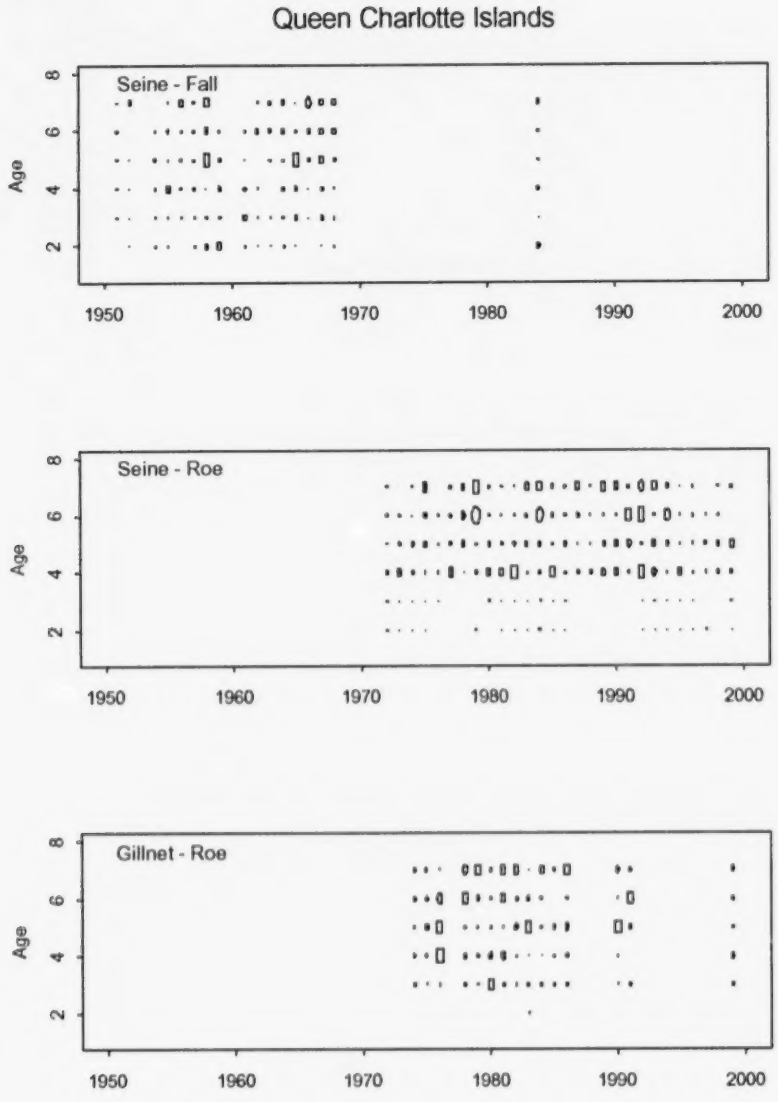

Figure 4.7. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijt}) for the Queen Charlotte Islands stock assessment region during three modelled fishing periods from 1951-1999. Ellipses denote positive residuals and rectangles negative residuals.

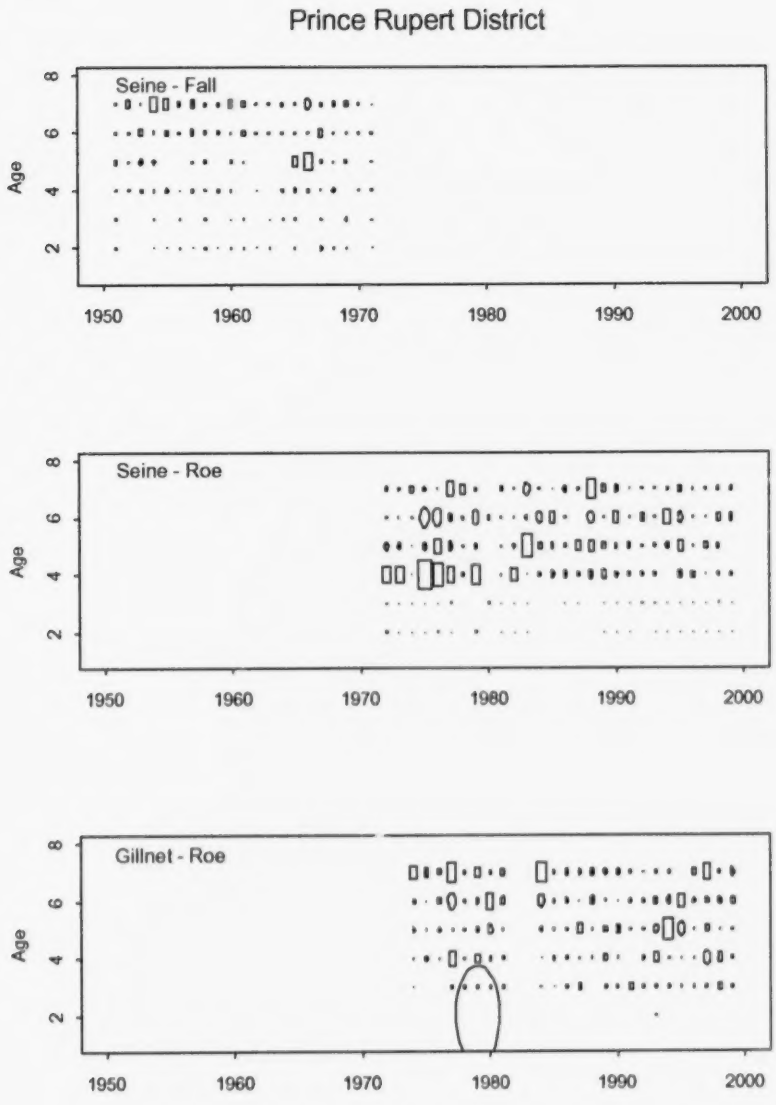

Figure 4.8. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Prince Rupert District stock assessment region during three modelled fishing periods from 1951-1999. Ellipses denote positive residuals and rectangles negative residuals.

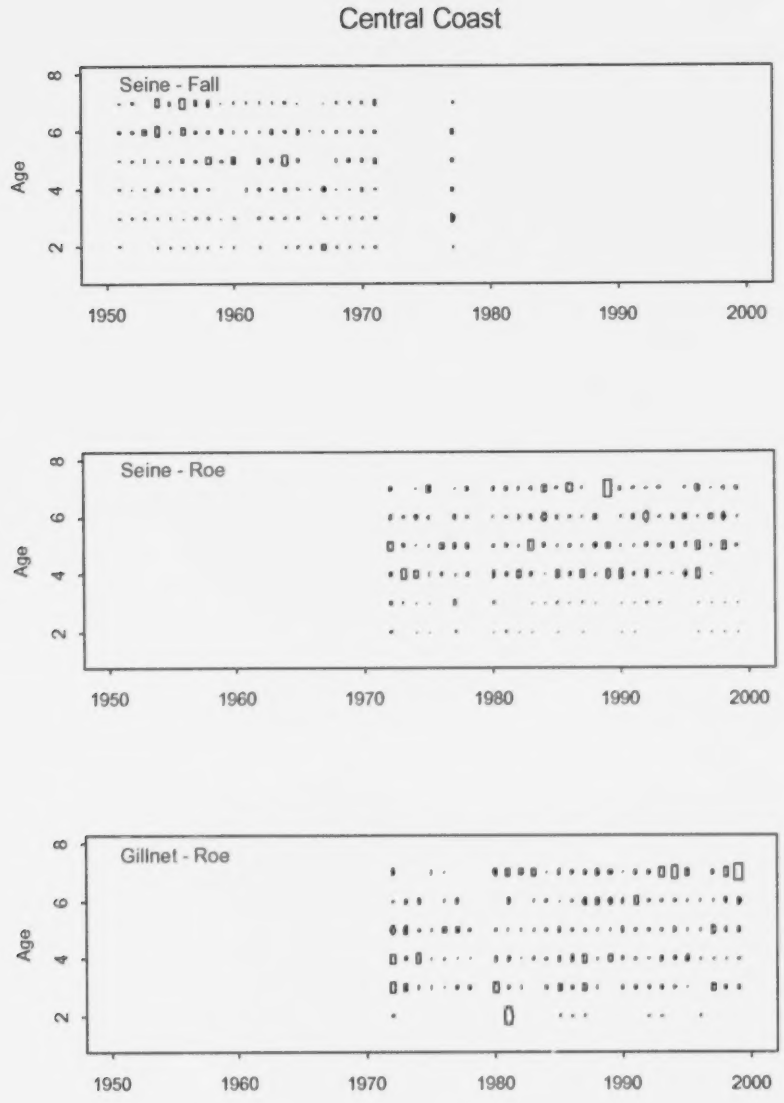

Figure 4.9. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Central Coast stock assessment region during three modelled fishing periods from 1951-1999. Ellipses denote positive residuals and rectangles negative residuals.

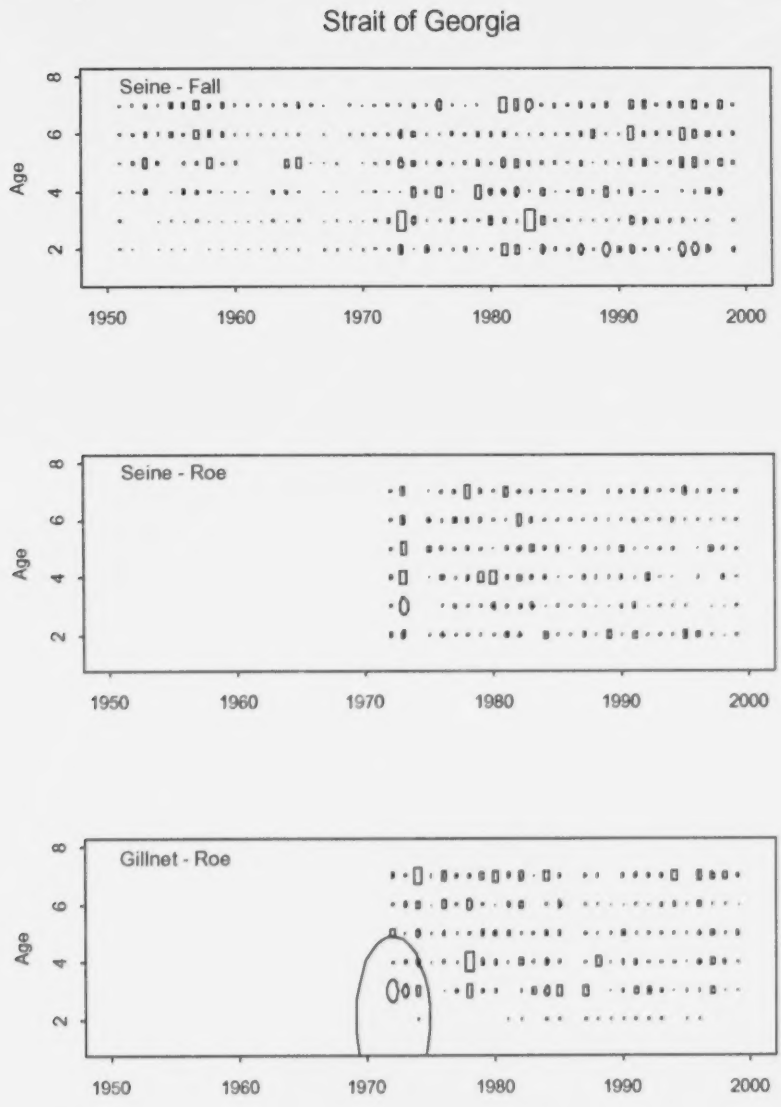

Figure 4.10. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the Strait of Georgia stock assessment region during three modelled fishing periods from 1951-1999. Ellipses denote positive residuals and rectangles negative residuals.

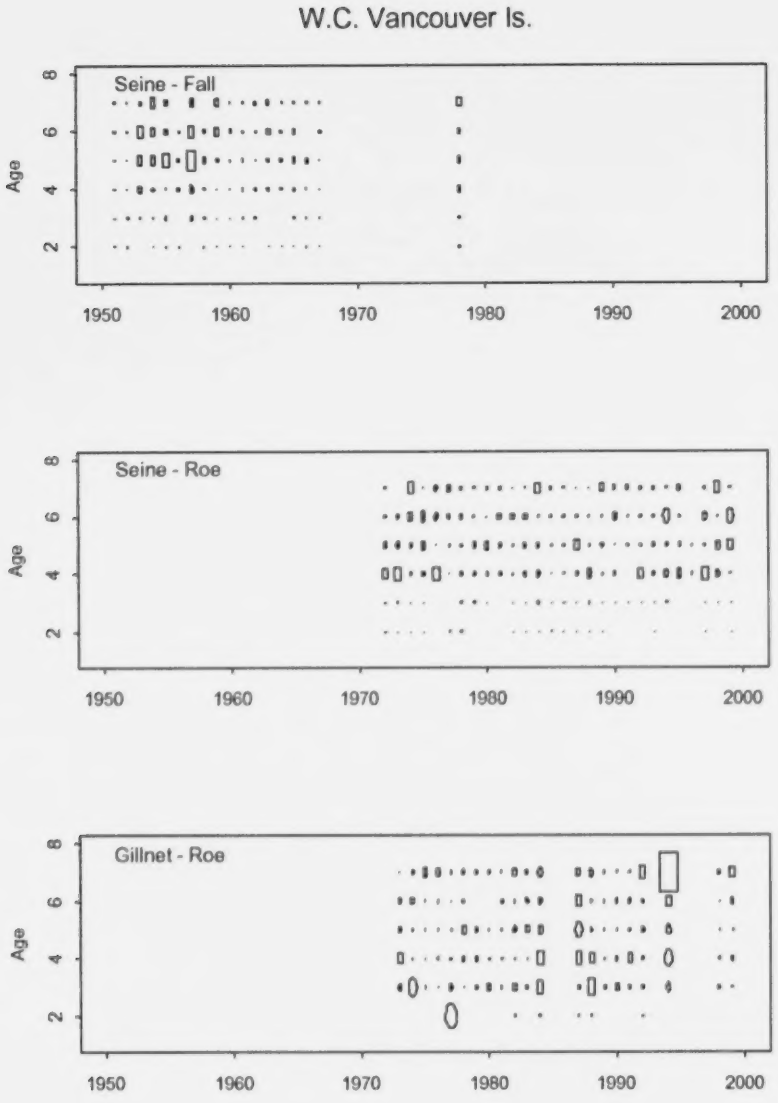

Figure 4.11. Standard deviates for the observed minus predicted proportions-at-age (Z_{ijr}) for the west coast of Vancouver Island stock assessment region during three modelled fishing periods from 1951-1999. Ellipses denote positive residuals and rectangles negative residuals.

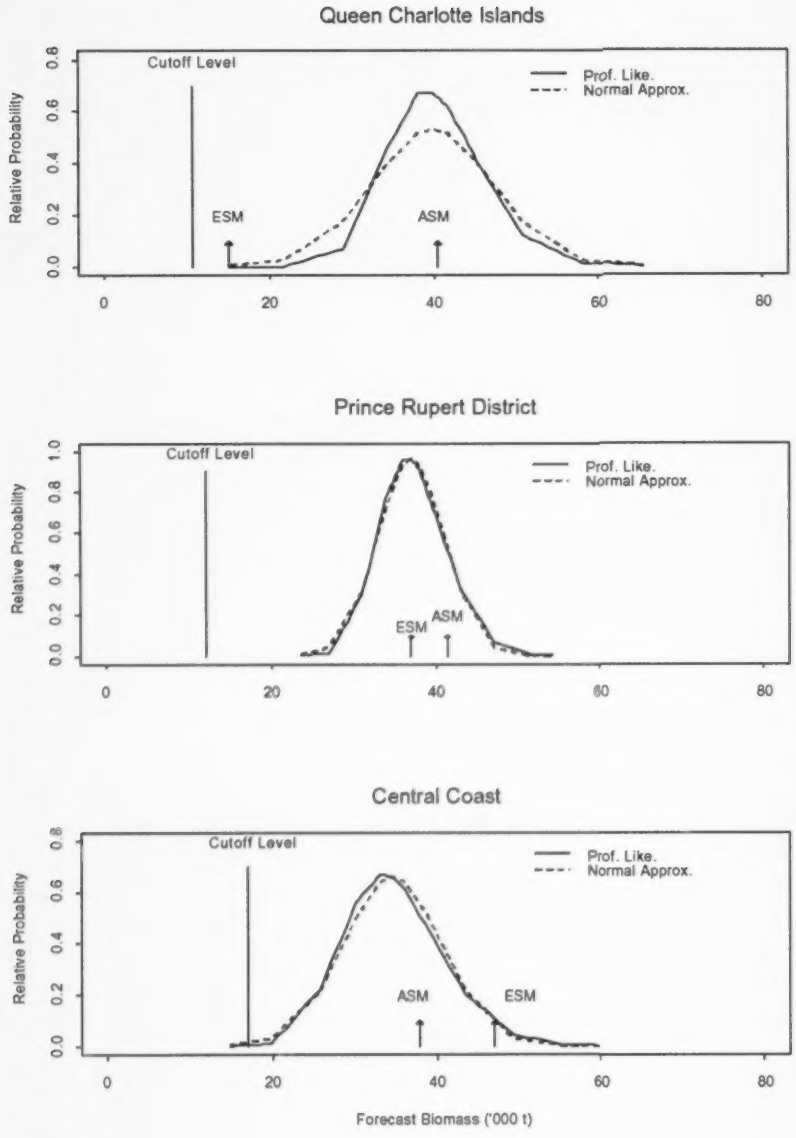

Fig. 4.12. Estimated Bayesian profile likelihood distributions and their normal approximations for the forecast 2000 mature biomass in the northern stock assessment regions. The arrows denote the forecasts assuming average recruitment for escapement and age-structured models.

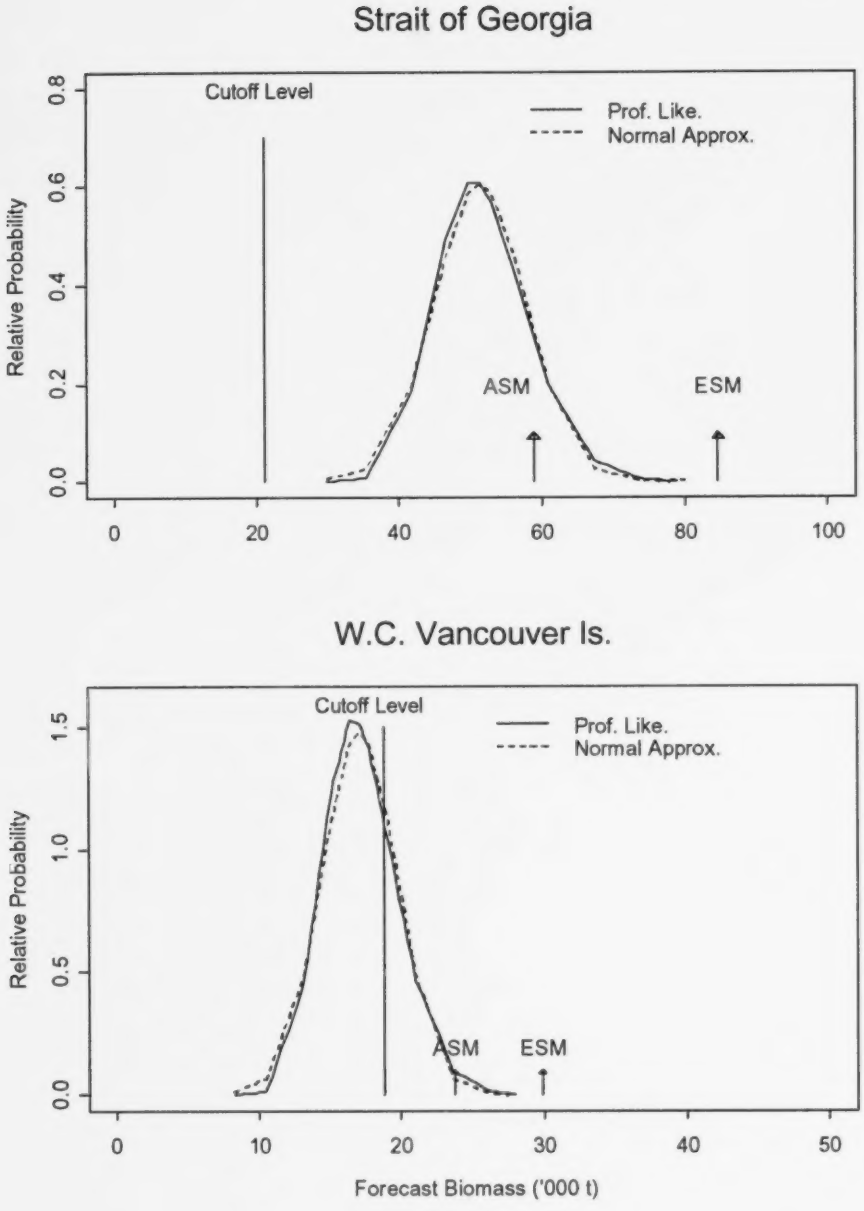

Fig. 4.13. Estimated Bayesian profile likelihood distributions and their normal approximations for the forecast 2000 mature biomass in the southern stock assessment regions. The arrows denote the forecasts assuming average recruitment for escapement and age-structured models.

5. RETROSPECTIVE ANALYSES

Age-structured Model

Schweigert (1996) presented a retrospective analysis for the herring age-structured model that indicated a tendency for slight over-forecasting in the northern assessment regions and under-forecasting in the southern assessment areas. An explanation for this conflicting trend was not evident but appears to be related to the inverse relationship between estimated natural mortality and the spawn index conversion factor. This effect persists in the current assessment which has been updated to include retrospective plots to and including the current year (Fig. 5.1, 5.2). In the northern assessment areas estimates of current spawning biomass and consequent forecasts of run sizes have been very consistent with a few minor exceptions in the Queen Charlotte Islands and Central Coast. Estimates for Prince Rupert have generally been much too high but recent assessments are more consistent. In the southern assessment regions, stock reconstructions have been conservative in both the Strait of Georgia and to a lesser extent on the west coast of Vancouver Island. Further investigation of the causes of the underestimates in the south is required.

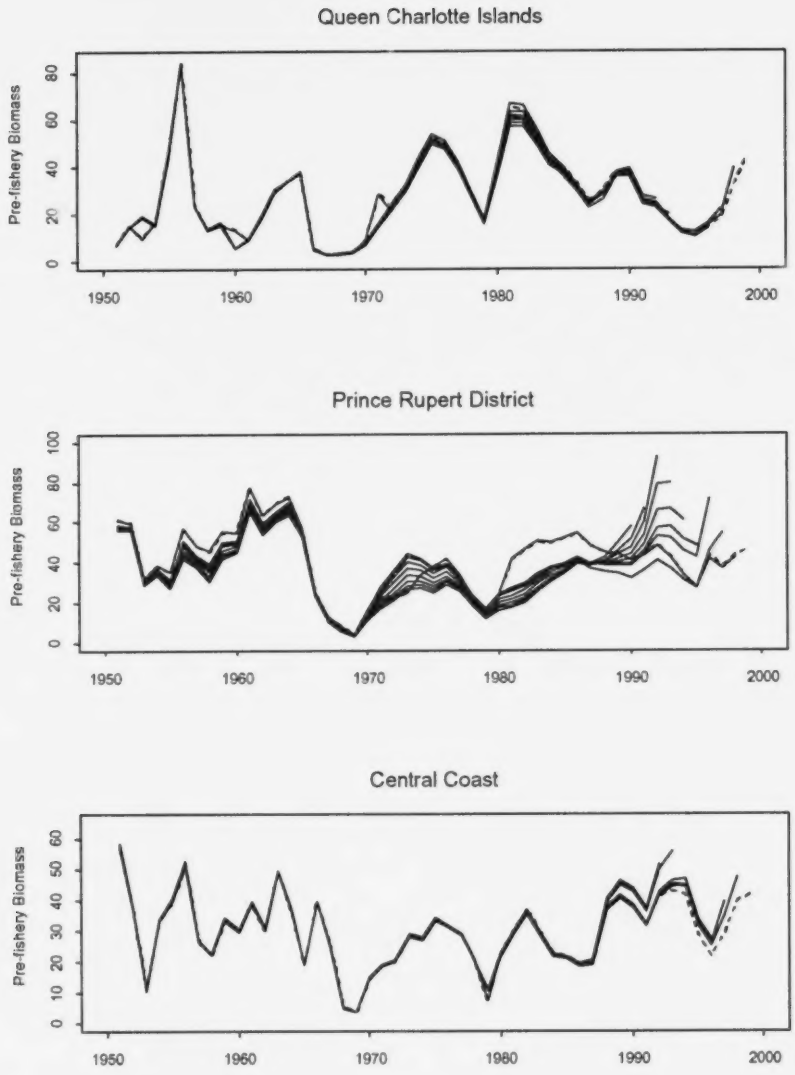

Figure 5.1. Retrospective analysis of estimated spawning biomass from age-structured assessment for northern B.C. herring stocks from 1951-1999. Dashed line indicates the most recent assessment.

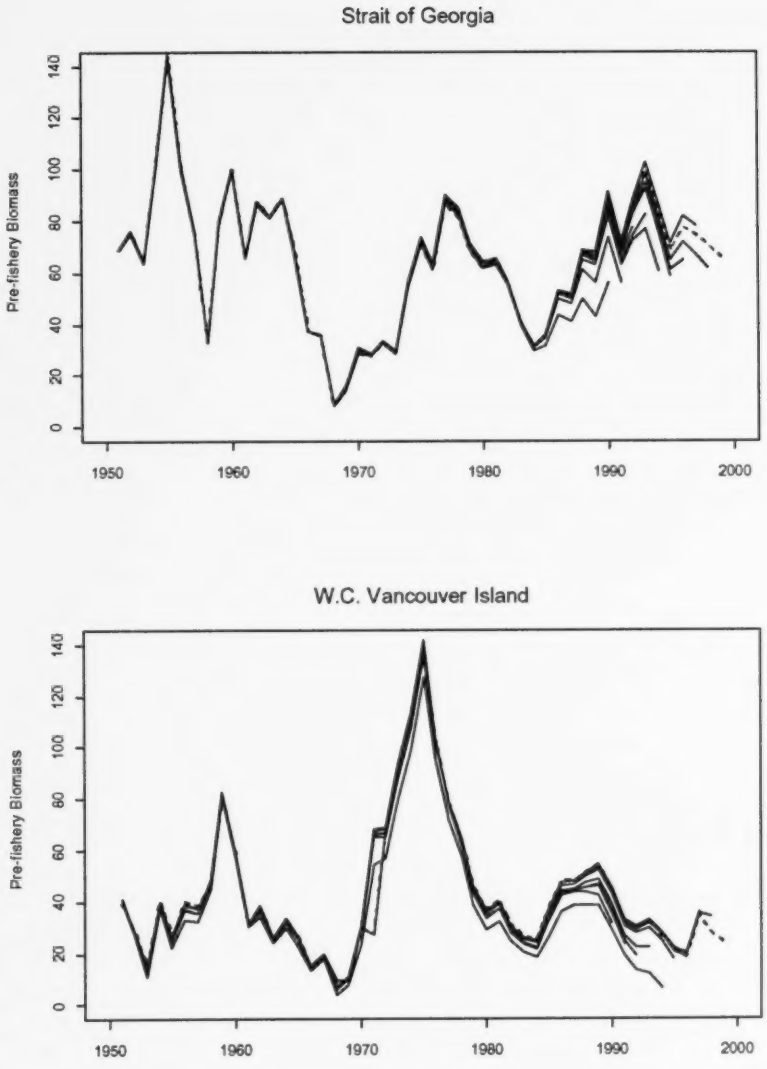

Figure 5.2. Retrospective analysis of estimated spawning biomass from age-structured assessment for southern B.C. herring stocks from 1951-1999. Dashed line indicates the most recent assessment.

6. VPA ANALYSIS AND MODEL VALIDATION

At the 1998 PSARC meeting, one review questioned whether some of the assumptions made by the age-structured model had been adequately tested. In particular, concern was expressed that the spawn index used to tune the ASM had not been validated as an unbiased estimator of spawning stock biomass. The other issue which was raised was whether time trends existed in the maturity or availability of herring to the fishery that could be affecting ASM performance. It was suggested that a traditional virtual population analysis (VPA) could be used to test these assumptions. A simple VPA was performed using an Excel spreadsheet provided by Carl Walters (UBC). Several versions of the spreadsheet were developed by Dr. Walters and analyses conducted to successively mimic many of the assumptions in the herring ASM and they all provided broadly similar results. However, we conducted and present the results only from a very basic VPA which was tuned by setting a terminal fishing mortality rate in the final year and at the oldest age to provide estimates of population egg production that were similar to those observed in the spawn surveys (Fig. 6.1). The natural mortality rate was assumed to be constant with age and the same as estimated by the ASM analysis in each area. Thus, the tuning parameters used for each stock were:

Stock	QCI	PRD	CC	GS	WCVI
Terminal Year Mortality Rate	0.15	0.20	0.30	0.20	0.20
Terminal Age Mortality Rate	0.25	0.15	0.25	0.10	0.15
Natural Survival Rate	0.64	0.59	0.76	0.55	0.65

Figure 6.1 illustrates the time series of egg production estimates from the VPA and the corresponding spawn index estimates from the spawn surveys which are used to tune the ASM. A scatter plot of these estimates is also provided to demonstrate the linearity in the relationship between the two estimates. While the terminal mortality rates chosen for the VPA were intended to provide a reasonable fit to the two data series the values obtained are very similar to the 20% harvest rate policy that has been in place since 1983 and so comparable to the mortality rate we believe to be in effect on the populations. The good agreement between the VPA and ASM estimates does indeed support the contention that the spawn index is an accurate reflection of the spawning biomass in most areas in most years.

The issue of time trends in vulnerability or availability to the fishery or mature biomass is more problematical. The herring ASM estimates annual availability parameters for age 1^+ and 2^+ fish and estimates single parameters for partial recruitment of age 3^+, 4^+ and 5^+ fish and assumes that all older age classes are fully recruited to the spawning stock. We calculated comparable estimates of apparent vulnerability from the VPA as the ratio of the catch at age to the estimated numbers at age divided by the estimated fishing mortality at age. The results are presented in Figures 6.2-6.6. The top two panels of each plot present the ASM estimate of availability and the corresponding vulnerability estimate from the VPA. The bottom two panels of each plot present the estimates of vulnerability from the VPA alone for ages 3^+-5^+ and 6^+-8^+. In general, the estimated vulnerabilities for age 1^+ fish from the ASM and VPA correspond quite well. For most areas the vulnerabilities for age 2^+ agree quite well since 1970 but are much lower for the ASM prior to this time. The VPA estimates of vulnerability for the older age classes are quite variable but generally indicate that vulnerabilities were higher prior to 1970 than in

subsequent years. However, it should also be noted that the VPA analysis is seriously affected by missing or biased estimates of catch at age which almost certainly occurred during the reduction closure (1968-72) and at other times for strikes (1952/53, 1958/59), and at various times during the roe fishery for conservation concerns. This may account for some of the incredibly high estimates of vulnerability by the VPA in the late 1960s. Hence, the issue of whether there have been significant changes in vulnerability over time that could be biasing ASM performance is not clear but suggestive.

Changes in vulnerability over time might be expected to affect estimates of year-class size in recent years relative to earlier years. To investigate this effect, we examined the estimated numbers of fish at age 2^+ from the VPA and the ASM for the five stocks in Figure 6.7. It is apparent that estimates of numbers at age from the VPA are slightly lower than the corresponding ASM estimates. This suggests that despite the apparent time trend in availabilities that are not incorporated into the ASM, this effect has not seriously affected the model's performance. Nevertheless, we decided to investigate alternative parameterizations of the ASM to attempt to incorporate time trends in availability into the ASM and assess the importance of this effect on model perfomance. Several alternative ASM model parameterizations were implemented and run for each stock. Selected results are presented in Table 6.1 for the base model, which is the current ASM implementation and eight alternative formulations. The alternative formulations are as follows and will be referred as A1-A8 in the following discussions:

A1: Lambda Roe/Red – separate λ for ages 3^+, 4^+, and 5^+ fish during red (1951-70) and roe (1971-99) periods;

A2: Lambda Roe/Red/2Q - separate λ for ages 3^+, 4^+, and 5^+ fish during red (1951-70) and roe (1971-99) periods plus separate estimates of the spawn conversion parameter prior to and after 1987 when dive surveys were implemented;

A3: Lambda 3 periods - separate λ for ages 3^+, 4^+, and 5^+ fish during 3 periods from 1951-65, 1966-80, 1980-1999;

A4: Knife 4-2 – knife-edge recruitment at age 3^+, independent parameters for each year for age 1^+ fish and one parameter for each of age 2^+, and 3^+ fish and older ages are fully available;

A5: Knife 6-23roe/red – similar to base model, knife-edge recruitment at age 6, independent parameters for each year for age 1^+ and 2^+ fish, and one parameter for ages 3^+ and 4^+ in both reduction and roe periods.

A6: Knife 6-2roe/red – similar to above, knife-edge recruitment at age 5^+, independent parameters for each year for age 1^+ fish, and one parameter for ages 2^+, 3^+, and 4^+ in both reduction and roe periods.

A7: Knife 5-23roe/red - knife-edge recruitment at age 4^+, independent parameters for each year for age 1^+ and 2^+ fish, and one parameter for age 3^+ fish in both reduction and roe periods.

A8: Knife 5-2roe/red – similar to above, knife-edge recruitment at age 4^+, independent parameters for each year for age 1^+ fish, and one parameter for age 2^+ and 3^+ fish in both reduction and roe periods.

Statistical comparison among a suite of alternative models with varying numbers of parameters and differing structural assumptions is notoriously difficult. Likelihood ratio tests may be useful when alternative models are nested subsets of a base model but this is rarely possible in most practical situations. One alternative measure of goodness of fit is the Akaike information criterion or AIC (Venables and Ripley 1994) which is simply:

AIC = -2 • maximized log likelihood + 2 • number parameters.

The other parameters of interest presented in Table 6.1 are the estimate of the objective function value at the minimum (which is equivalent to the log likelihood at the maximum above), the estimate of the natural mortality rate (M), the estimate of the spawn conversion parameter (Q), the estimate of the 1999 total mature biomass, and the forecast of the 2000 biomass of adult mature stock (ages 3^+ and older).

The results for the Queen Charlotte Islands indicate 5 alternative formulations (A1-A3, A5, A7) with AIC values similar to or lower than the base model. All but A2 result in 1999 biomass and 2000 forecast biomass substantially higher than the base model. They also all result in estimates of M higher than seems reasonable.

The analysis for the Prince Rupert stock suggests that 4 of the alternative formulations (A1-A3, A5) with lower AIC values may provide better fits to the available data. Unfortunately, all again suggest both higher current and future biomass and natural mortality rates than for the base model.

The ASM assessment for the Central Coast has been questioned because of the apparently low estimate of M. The alternative assessment conducted here with lower AIC estimates than the base model (A1-A3, A5, A7) all result in significantly higher estimates of both M and biomass. While the estimate of M is plausible the resulting estimates of total biomass are unrealistic based on in-season soundings and spawn deposition in the area.

The results for the Strait of Georgia again indicate several AIC values lower than for the base model (A1-A3, A5, A7). Concerns in recent assessments about the apparently high M value for this area are exacerbated by the alternative models which all have higher estimates of M. The spawning biomass estimate of the base model appears low relative to the ESM. Models A5 and A7 both appear to provide reasonable alternatives to the base model.

The analysis for the west coast of Vancouver Island identified 5 models with lower AIC estimates than the base model (A1-A3, A5, A7). All provide estimates of M and biomass substantially higher than the base model, although both A5 and A7 provide plausible estimates.

Overall, the alternative model formulations do provide some support for the observation that availability has not been constant over time. While there is not strong support for any particular formulation in all areas, it appears that model A7 may provide a useful alternative to the current formulation for the two southern stocks since it assumes full maturation at an earlier age and provides for different availability schedules in the roe and reduction periods. It may also address some of the retrospective problems in these two stocks. This formulation may or may not be appropriate for the northern stocks where no clear alternative to the current formulation was evident. The retrospective performance of A7 should be investigated over the next year to evaluate its merit as an alternative to the current formulation of the ASM in all areas.

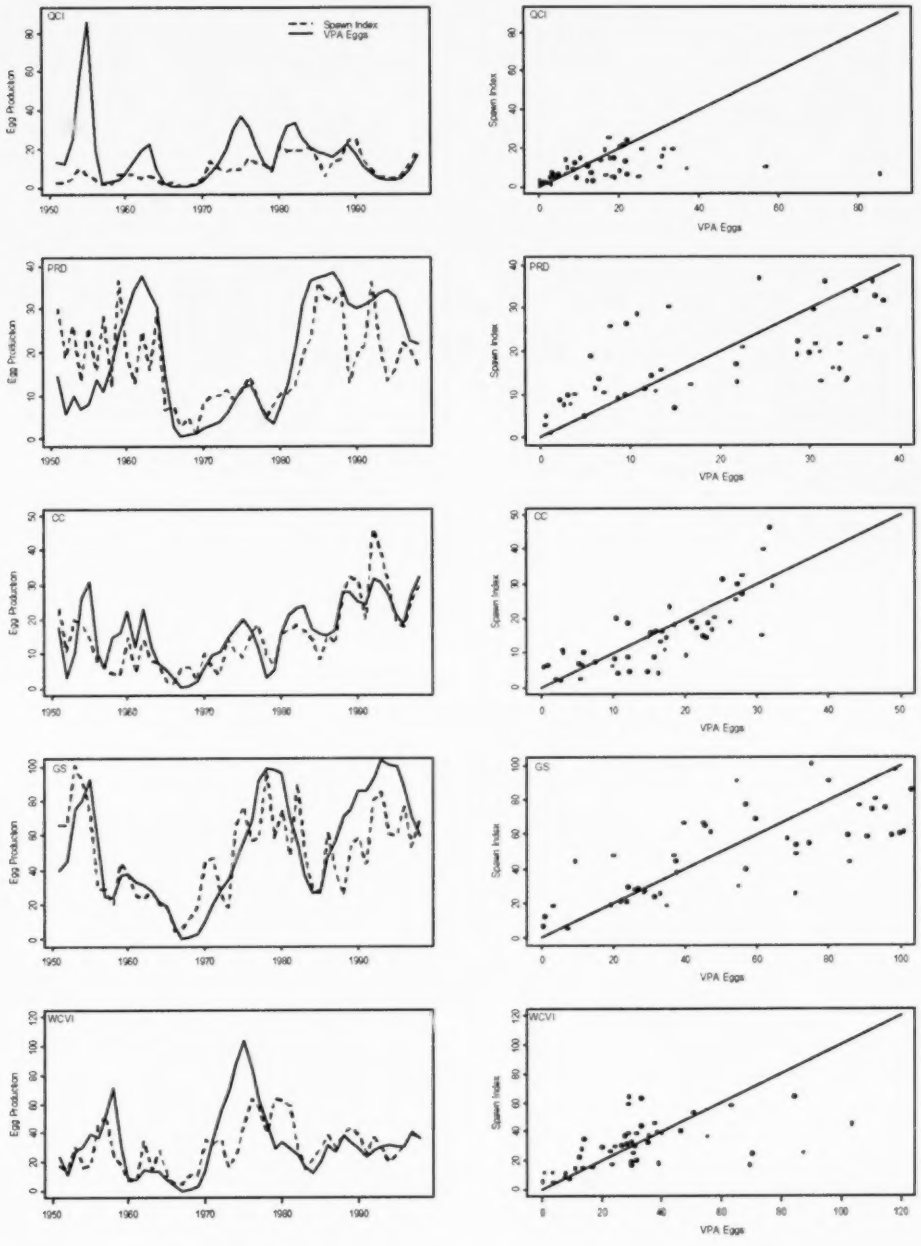

Figure 6.1. Time series and scatter plots of the spawn index and egg production estimates from VPA analysis from 1951-1999. The line represents the 1:1 correspondence between the two estimates.

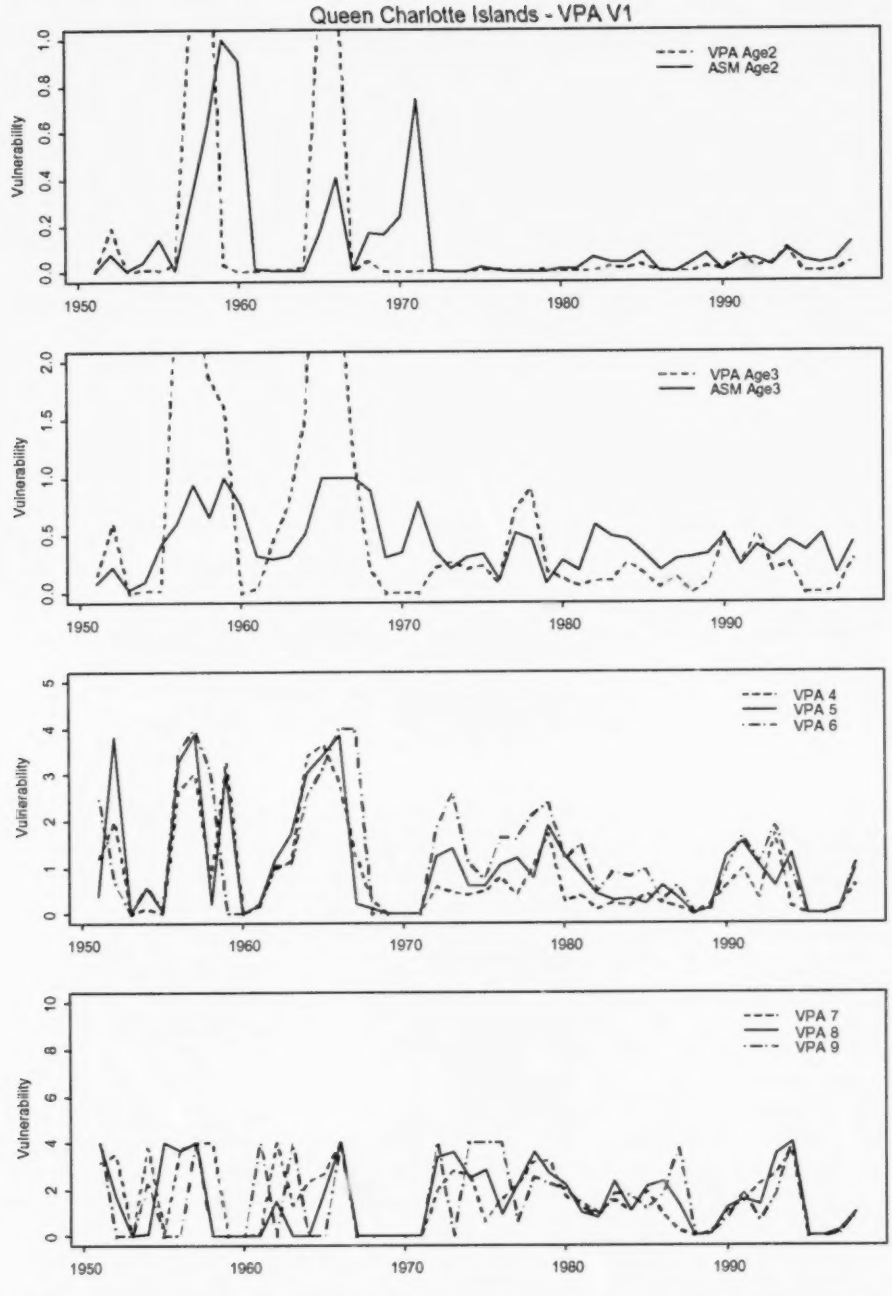

Figure 6.2. Vulnerability and availability estimates from ASM (panels 1 and 2) and VPA for all age classes for the Queen Charlotte Islands from 1951-1999.

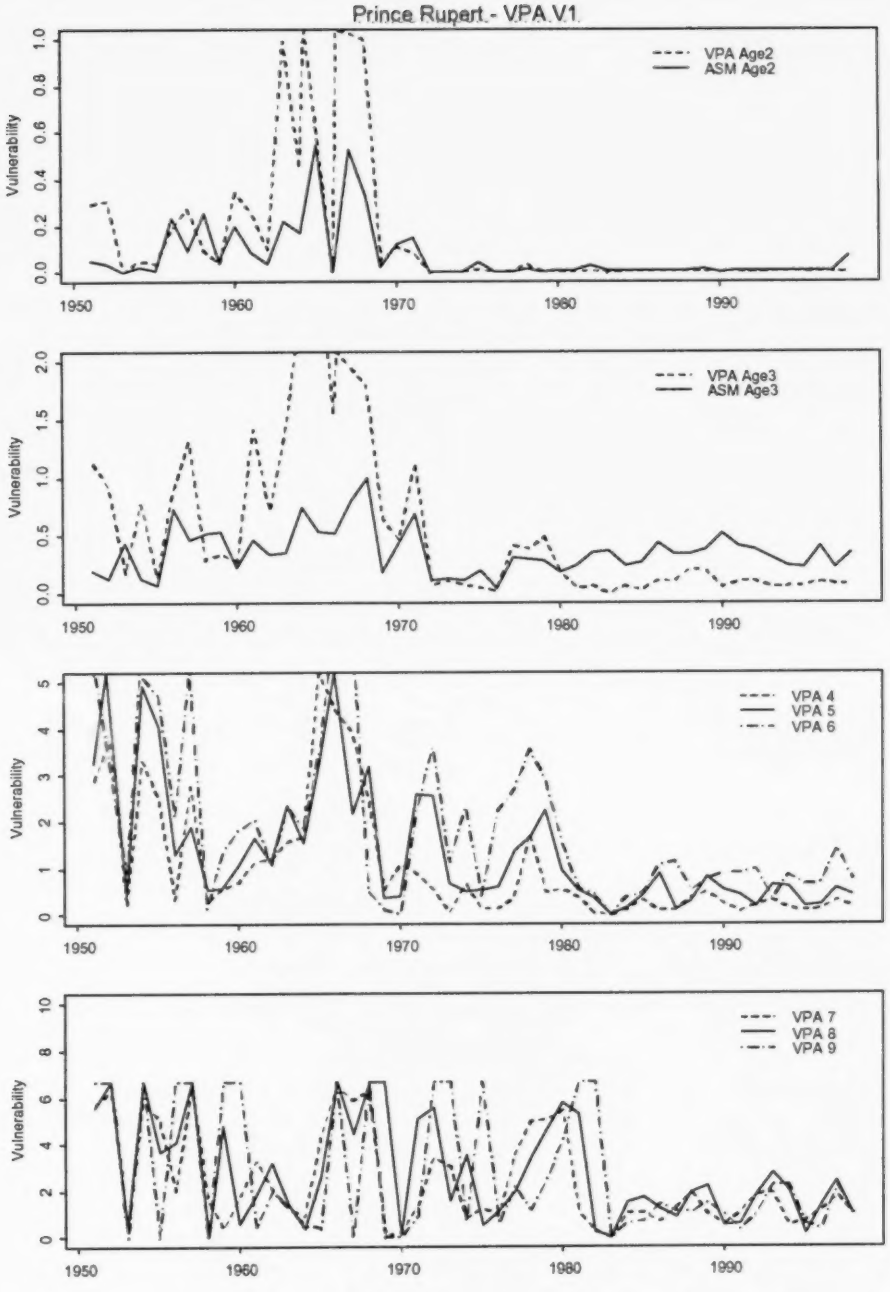

Figure 6.3. Vulnerability and availability estimates from ASM (panels 1 and 2) and VPA for all age classes for the Prince Rupert District from 1951-1999.

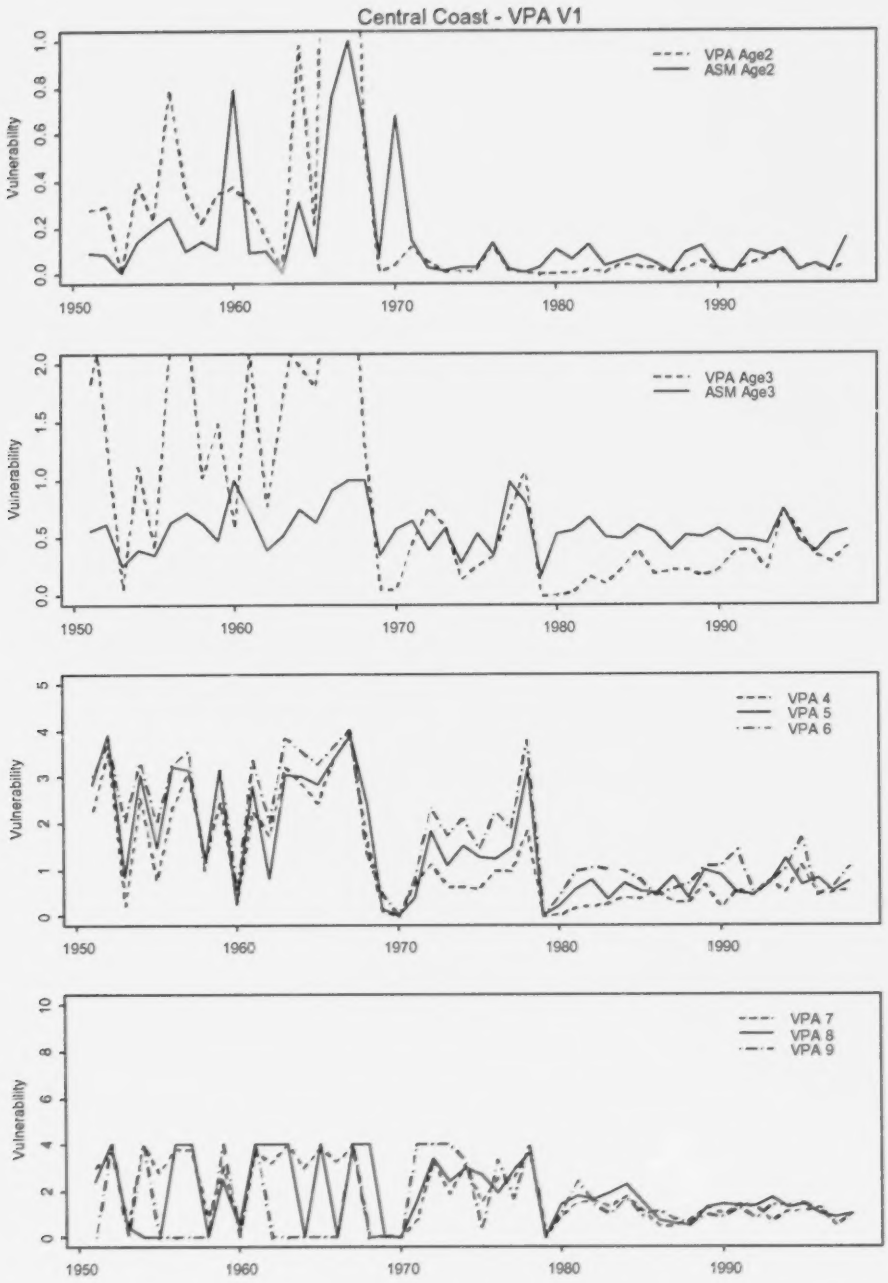

Figure 6.4. Vulnerability and availability estimates from ASM (panels 1 and 2) and VPA for all age classes for the Central Coast from 1951-1999.

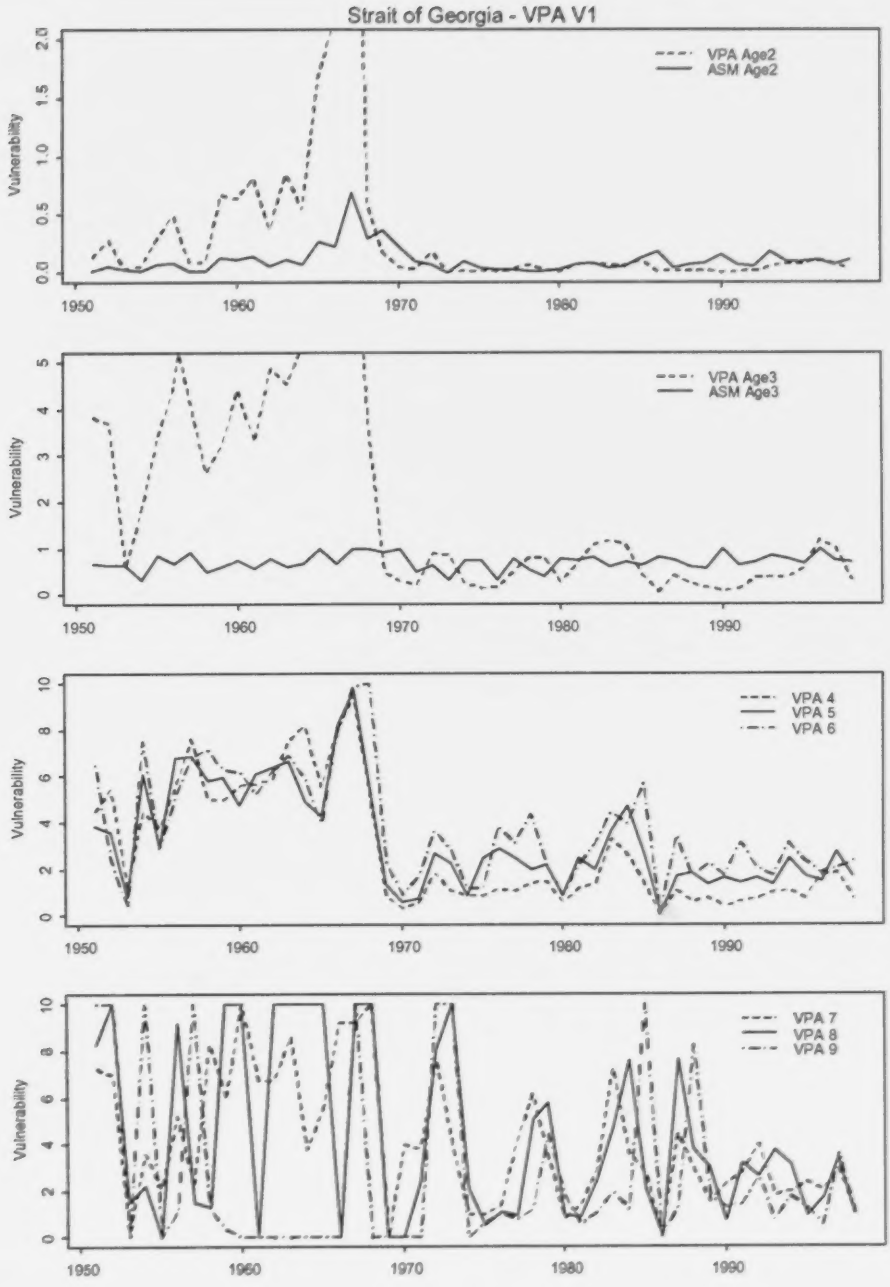

Figure 6.5. Vulnerability and availability estimates from ASM (panels 1 and 2) and VPA for all age classes for the Strait of Georgia from 1951-1999.

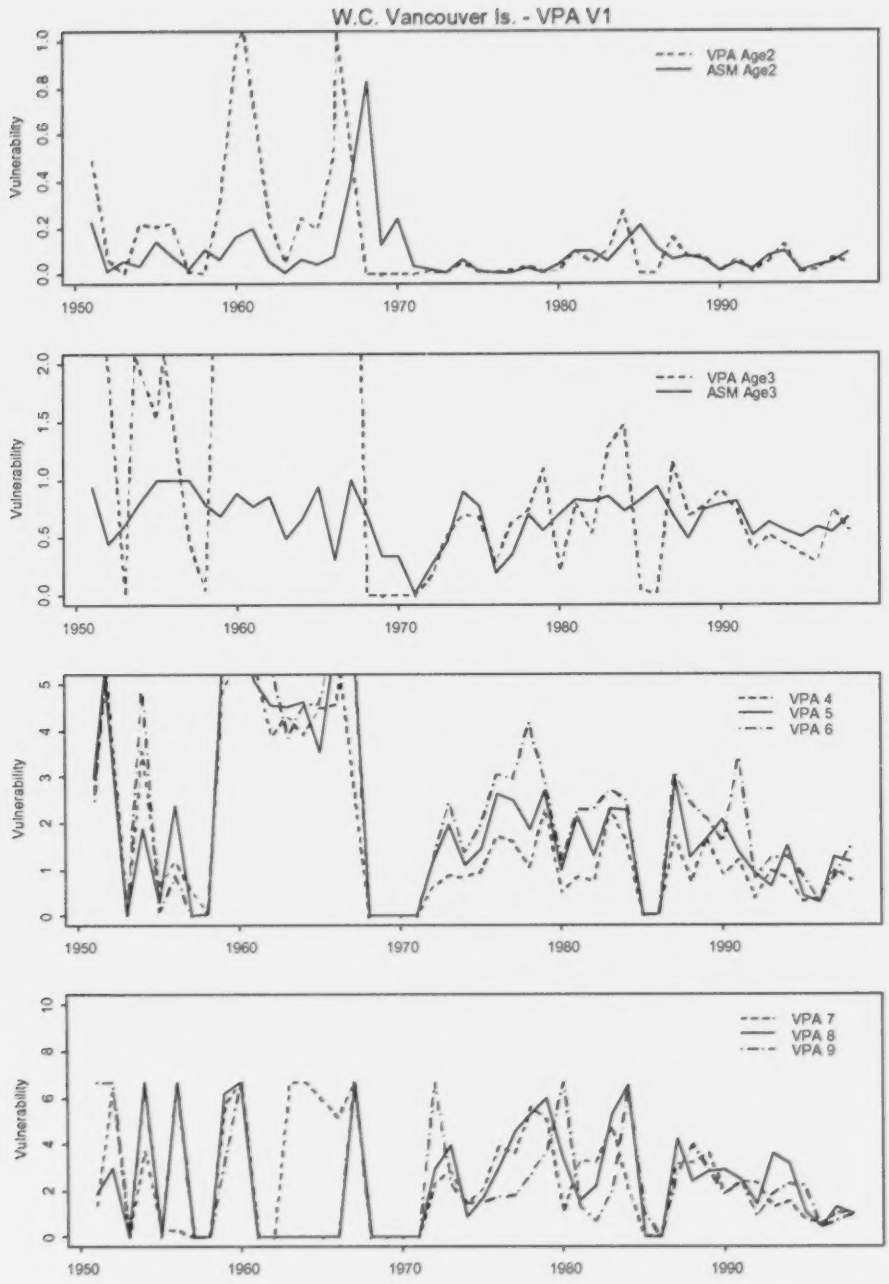

Figure 6.6. Vulnerability and availability estimates from ASM (panels 1 and 2) and VPA for all age classes for the west coast Vancouver Island from 1951-1999.

Table 6.1. Comparison of various parameterizations of availability for the herring ASM, key parameters, and the AIC measure of goodness of fit for the five major stocks.

	Number Parameters	Function Value	AIC	M	Q	1999 Biomass	2000 Forecast
QCI							
Base	222	602	1046	0.46	0.46	44164	37052
Lambda Roe/Red	225	549	999	0.60	0.35	53684	46756
Lam-Roe/Red/2Q	226	544	996	0.63	0.33/0.55	32285	26934
Lambda 3periods	228	533	989	0.67	0.29	64298	56163
Knife 4-2	172	1148	1492	0.46	0.19	84524	57114
Knife 6-23roe/red	223	552	998	0.53	0.35	56128	49032
Knife 6-2 roe/red	177	814	1168	0.56	0.18	101182	85015
Knife 5-23roe/red	221	614	1056	0.46	0.37	55231	49006
Knife 5-2 roe/red	175	864	1214	0.51	0.19	94749	80426
PRD							
Base	235	1201	1671	0.52	0.58	46474	35959
Lambda Roe/Red	238	1121	1597	0.62	0.39	76179	58974
Lam-Roe/Red/2Q	239	1120	1598	0.63	0.37/0.42	68359	52513
Lambda 3periods	241	914	1396	0.63	0.42	50314	35872
Knife 4-2	185	2209	2579	0.26	0.80	39393	31339
Knife 6-23roe/red	236	1121	1593	0.62	0.39	76177	58973
Knife 6-2 roe/red	190	1662	2042	0.56	0.51	60315	47501
Knife 5-23roe/red	234	1290	1758	0.42	0.62	43575	35500
Knife 5-2 roe/red	188	2198	2574	0.40	0.68	44656	36904
CC							
Base	238	564	1040	0.28	0.92	41698	34047
Lambda Roe/Red	241	508	990	0.51	0.64	68621	57585
Lam-Roe/Red/2Q	242	507	991	0.51	0.64/0.71	60709	50349
Lambda 3periods	244	503	991	0.53	0.63	63879	52269
Knife 4-2	188	1142	1518	0.15	1.00	19123	10804
Knife 6-23roe/red	239	519	997	0.39	0.66	66750	57084
Knife 6-2 roe/red	193	755	1141	0.47	0.49	78019	65954
Knife 5-23roe/red	237	570	1044	0.28	0.82	50890	42855
Knife 5-2 roe/red	191	844	1226	0.39	0.54	64404	52186
GS							
Base	265	1157	1687	0.59	1.26	65979	38125
Lambda Roe/Red	268	1129	1665	0.78	0.97	79233	43737
Lam-Roe/Red/2Q	269	1117	1655	0.65	1.46/0.79	106765	66174
Lambda 3periods	271	1107	1649	0.73	1.09	66446	36056
Knife 4-2	215	1732	2162	0.55	1.12	106312	67362
Knife 6-23roe/red	266	1134	1666	0.67	1.01	78870	45251
Knife 6-2 roe/red	220	1699	2139	0.67	0.92	123678	77992
Knife 5-23roe/red	264	1143	1671	0.65	1.02	77947	44967
Knife 5-2 roe/red	218	1709	2145	0.62	0.99	118094	74537
WCVI							
Base	229	1007	1465	0.45	1.18	24061	15770
Lambda Roe/Red	232	812	1276	1.05	0.35	67698	41067
Lam-Roe/Red/2Q	233	847	1313	0.67	0.82/0.71	44752	30164
Lambda 3periods	235	798	1268	1.18	0.15	155967	93942
Knife 4-2	179	1624	1982	0.30	1.53	16320	10003
Knife 6-23roe/red	230	867	1327	0.64	0.68	41700	28001
Knife 6-2 roe/red	184	1412	1780	0.59	0.85	36050	25649
Knife 5-23roe/red	228	964	1420	0.50	0.88	35557	23654
Knife 5-2 roe/red	182	1485	1849	0.48	0.96	32259	21753

7. MIGRATION AND NATURAL MORTALITY

During discussions at the 1998 assessment review it was noted that the natural mortality rate for the Strait of Georgia stock was unusually high while the rate estimated for the Central Coast stock was unusually low relative to the other three stocks. It was suggested that herring could be migrating from one area to the other thus biasing the estimates of natural mortality for these two stocks. To investigate this question we examined the estimates of the number of age 2^+ fish in each stock in relation to the number of age 2^+ fish in each of the other four stock areas and the number of age 3^+ fish in each stock next year relative to the number of age 3^+ fish in the other stocks next year, etc. If there was a net movement of fish from one area to another it should be evident from these plots. In other words, if there was an abundance of three year old fish in one area which subsequently moved to another area next year as 4 year olds or 5 year olds two years from now the effect should be evident as an increased abundance of fish in one of the other areas. The results are presented in Figures 7.1-7.5 and indicate that in all instances the relationship between the various pairs of areas are consistent over time and there are no significant differences between the scatterplots of age 2^+, 3^+, 4^+, or 5^+ fish in each pair of areas. Thus, there is no evidence for net movement of fish from one area to another on an ongoing basis which would be required to generate the apparent dichotomy in natural mortality rates between two stocks.

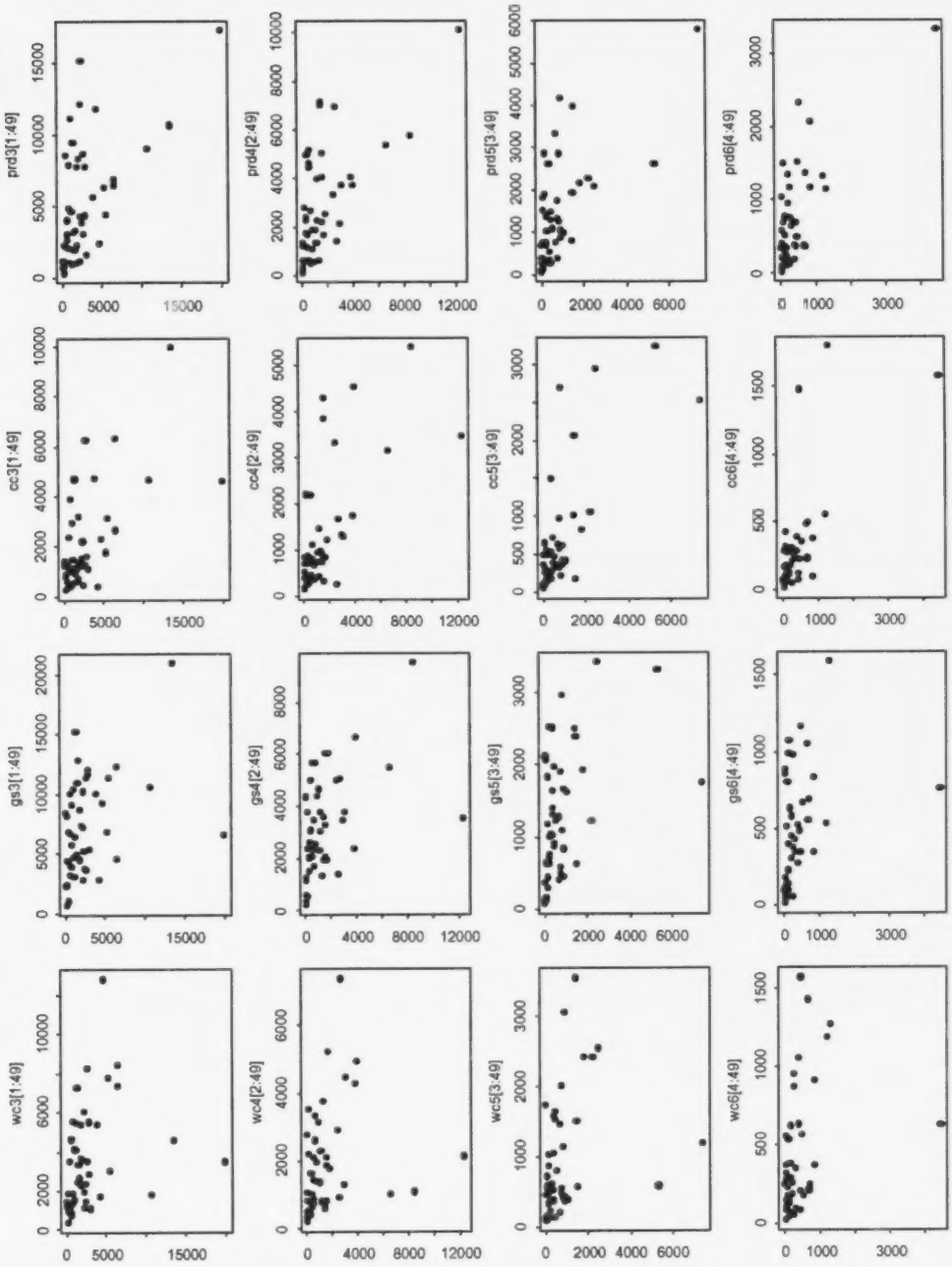

Figure 7.1. Scatter plots of the estimated number of age 2^+- 5^+ herring in the Queen Charlotte Islands (abscissa) and the numbers of age 2^+ fish in year n, age3^+ fish in year n+1, age 4^+ fish in year n+2, and age 5^+ fish in year n+3 for the other four assessment regions (PRD,CC,SG,WCVI).

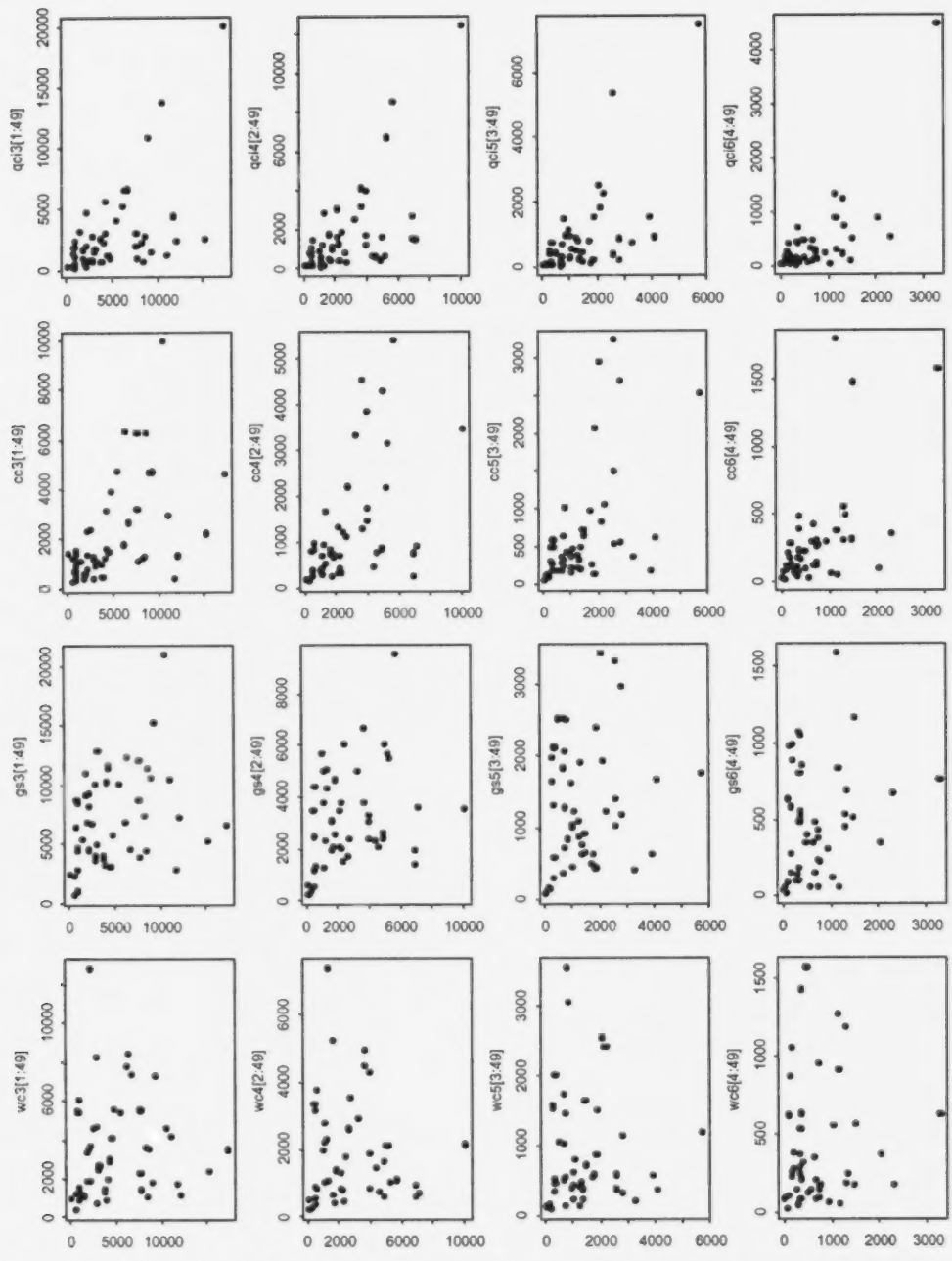

Figure 7.2. Scatter plots of the estimated number of age 2^+-5^+ herring in the Prince Rupert District (abscissa) and the numbers of age 2^+ fish in year n, age3^+ fish in year n+1, age 4^+ fish in year n+2, and age 5^+ fish in year n+3 for the other four assessment regions (QCI,CC,SG,WCVI).

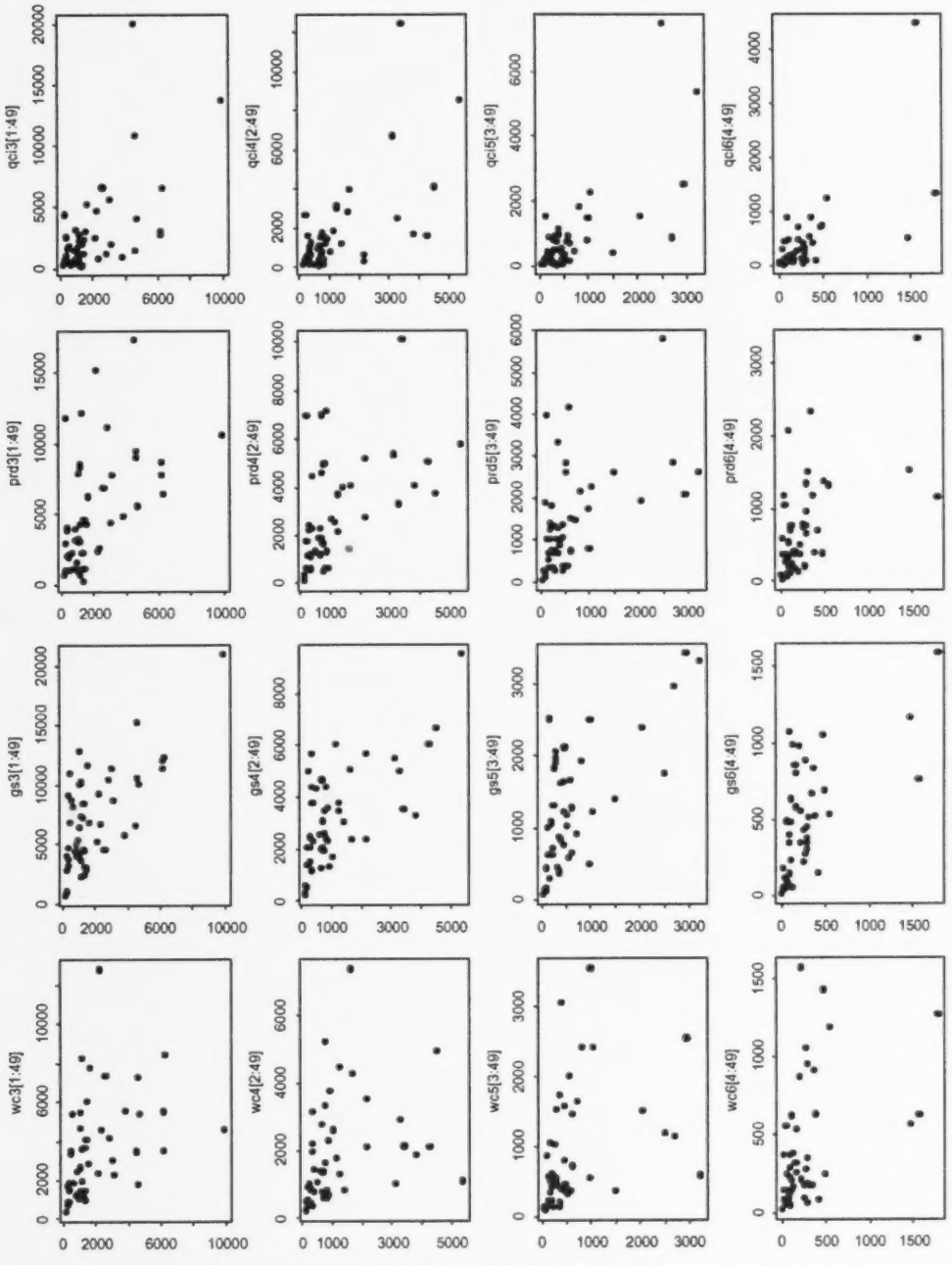

Figure 7.3. Scatter plots of the estimated number of age 2^+-5^+ herring in the Central Coast (abscissa) and the numbers of age 2^+ fish in year n, age3^+ fish in year n+1, age 4^+ fish in year n+2, and age 5^+ fish in year n+3 for the other four assessment regions (QCI,PRD,SG,WCVI).

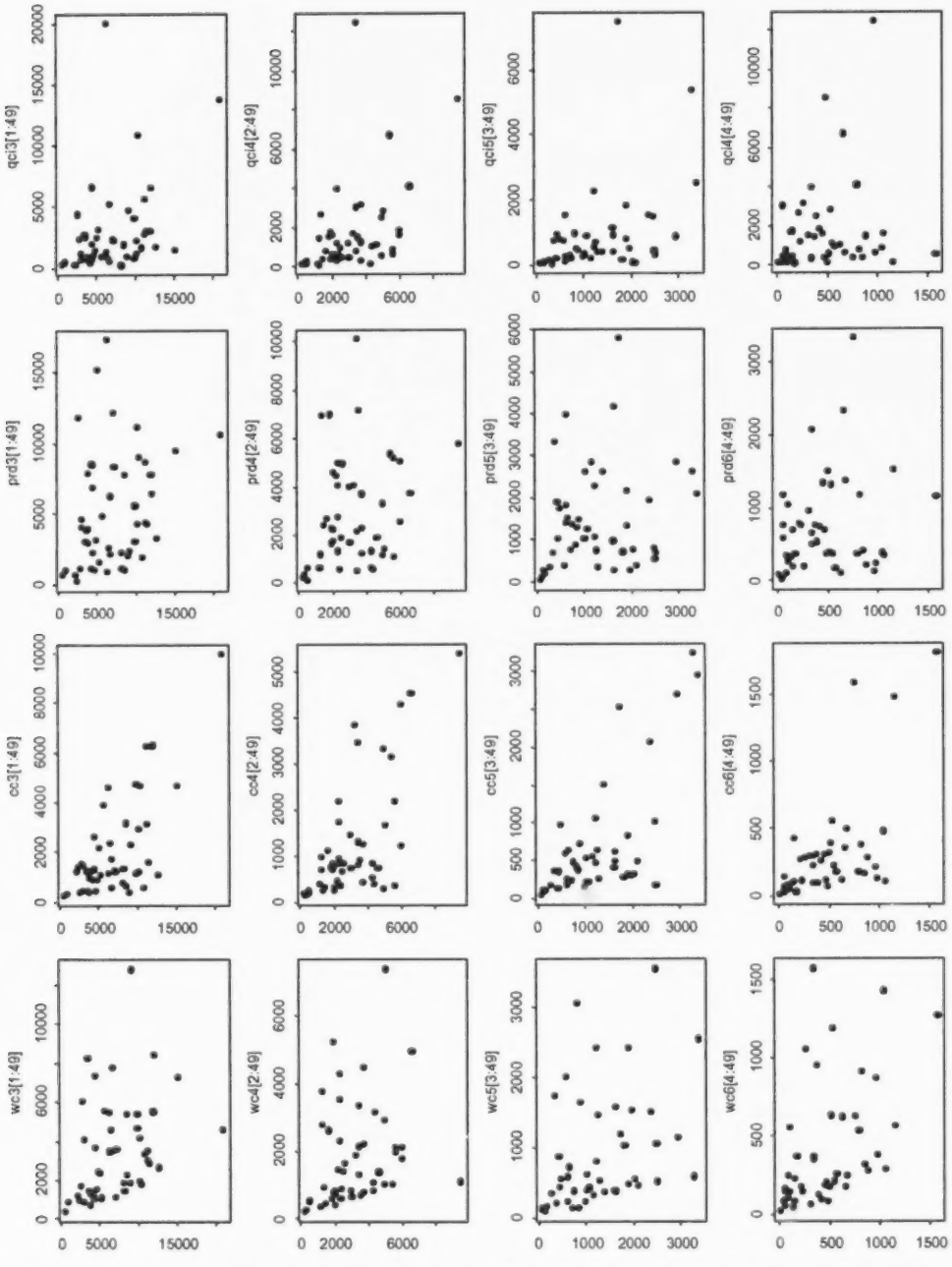

Figure 7.4. Scatter plots of the estimated number of age 2^{+}-5^{+} herring in the Strait of Georgia (abscissa) and the numbers of age 2^{+} fish in year n, age3^{+} fish in year n+1, age 4^{+} fish in year n+2, and age 5^{+} fish in year n+3 for the other four assessment regions (QCI,PRD,CC,WCVI).

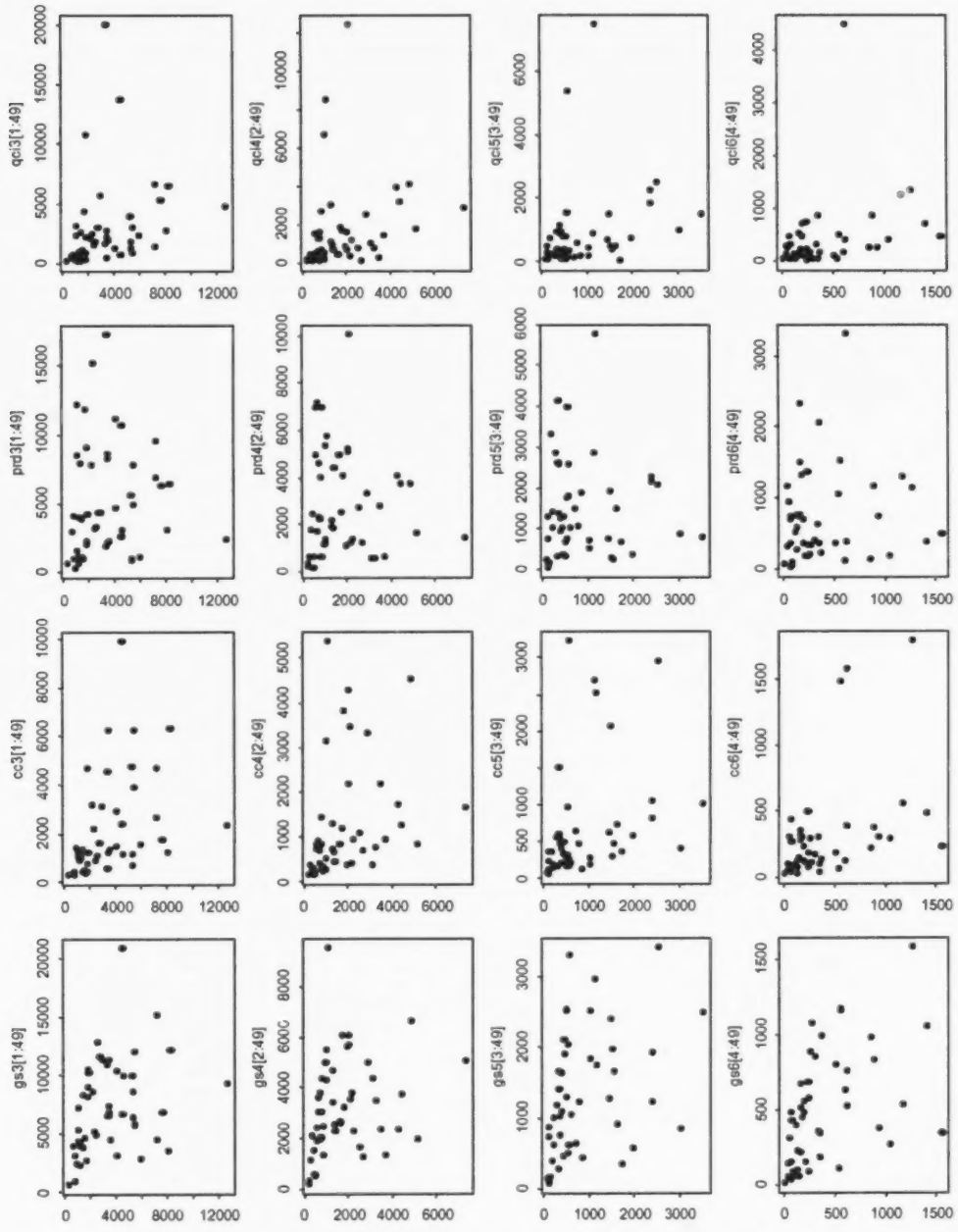

Figure 7.5. Scatter plots of the estimated number of age 2^+-5^+ herring in the west coast Vancouver Island (abscissa) and the numbers of age 2^+ fish in year n, age3^+ fish in year n+1, age 4^+ fish in year n+2, and age 5^+ fish in year n+3 for the other four assessment regions (QCI,PRD,CC,SG).

8. SIZE AT AGE TRENDS

A major issue during the 1998 assessment review was the recent downward trend in the size at age of herring and its impacts on estimates of forecast biomass as well as the availability and catchability of herring for the gillnet fleet. In the 1999 fishing plan adjustments were made to the available quotas to account for the decreased size of herring and the availability of sufficient catchable tonnages for the gillnet sector. Figure 8.1 presents the available data on size at age of herring since 1951 and indications are that sizes at age in 1999 has increased slightly for some age-classes in some areas over the previous year which should provide better opportunities for gillnet fisheries in some areas.

ACKNOWLEDGEMENTS

We are grateful to Carl Walters (UBC) for providing the Excel spreadsheets for the VPA analysis and for his interest and assistance in conducting other analyes. Lorena Hamer and Peter Midgley updated the catch and sampling data bases and reviewed all 1999 biological sampling data. Howard Stiff provided programming support for the Access databases used to summarize the catch and spawn data and was funded by the Herring Conservation and Research Society.

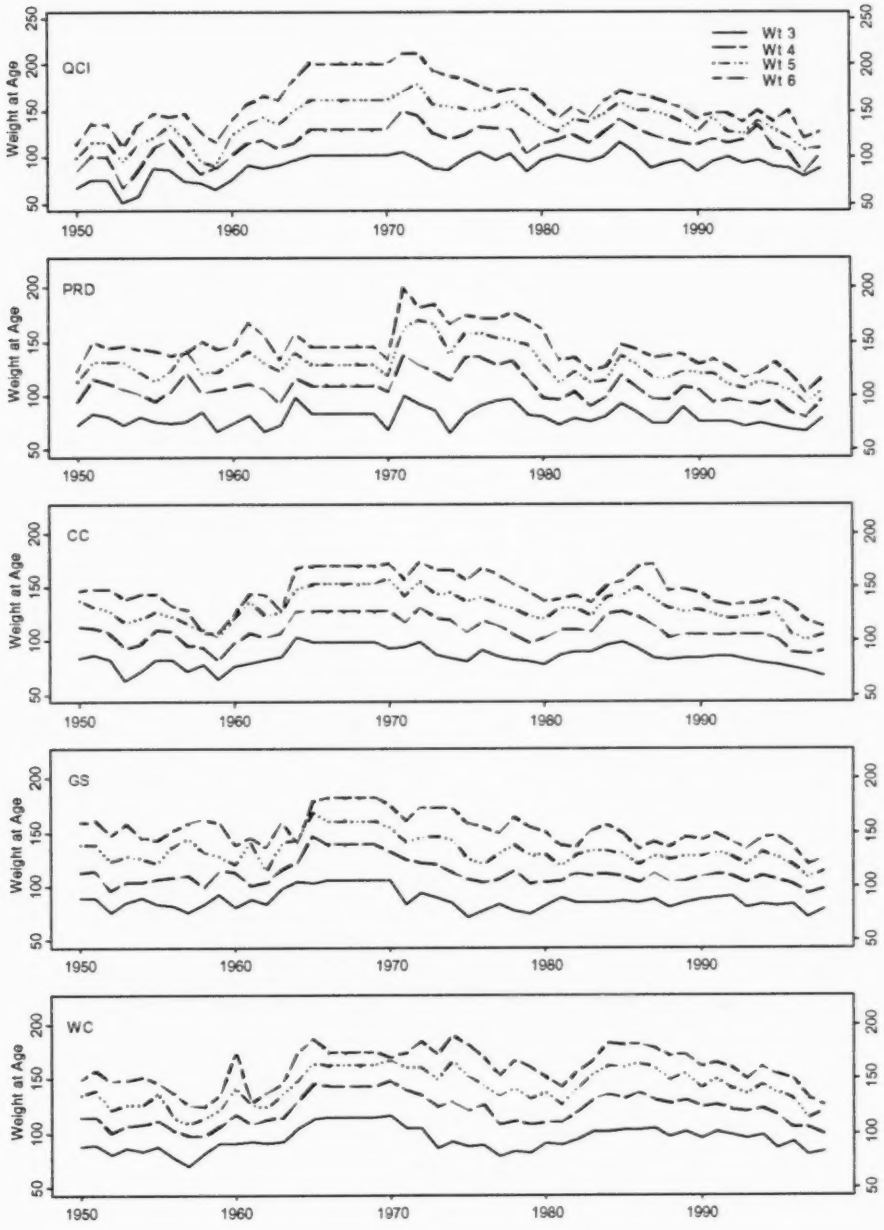

Figure 8.1. Estimates of weight-at-age (g) for 3-6 year old herring from 1951-1999 for the five major assessment areas.

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10. APPENDIX TABLES

Appendix Table 1.1. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Queen Charlotte Islands stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
1950/51	WINTER	0.07	15.31	52.91	15.31	11.52	4.20	0.61	0.07	0.00	1476	1544	317.44
1951/52	WINTER	17.13	21.81	34.17	21.54	4.14	1.12	0.09	0.00	0.00	2224	166	1124.25
1953/54	WINTER	2.96	29.02	21.28	33.66	10.19	1.93	0.71	0.19	0.06	0*	25	231.66
1954/55	WINTER	8.74	14.08	39.42	18.06	14.85	4.37	0.29	0.10	0.10	0*	25	52.94
1955/56	WINTER	0.15	16.02	9.64	62.17	8.38	2.74	0.74	0.00	0.15	1348	681	6551.83
1956/57	WINTER	20.77	24.13	15.76	9.59	26.73	2.45	0.44	0.13	0.00	4733	2180	2089.67
1957/58	WINTER	81.89	16.42	1.23	0.18	0.14	0.14	0.00	0.00	0.00	2838	514	2146.22
1958/59	WINTER	1.05	63.16	28.42	7.37	0.00	0.00	0.00	0.00	0.00	95	6	735.74
1960/61	WINTER	4.21	32.63	36.00	24.84	1.26	0.42	0.21	0.42	0.00	0*	25	59.00
1961/62	WINTER	3.04	37.62	41.36	9.58	6.54	1.64	0.23	0.00	0.00	428	170	693.85
1962/63	WINTER	0.37	50.00	27.11	18.16	2.11	1.99	0.00	0.12	0.12	804	411	1342.32
1963/64	WINTER	0.95	15.34	59.47	17.80	5.30	1.14	0.00	0.00	0.00	528	297	2515.06
1964/65	WINTER	1.61	79.77	11.02	4.37	2.09	0.95	0.19	0.00	0.00	1053	165	3424.55
1965/66	WINTER	18.36	32.77	16.38	10.40	7.45	5.89	4.92	2.07	1.75	0*	25	210.12
1966/67	WINTER	0.88	67.26	26.49	2.65	2.72	0.00	0.00	0.00	0.00	0*	25	18.83
1967/68	WINTER	29.95	50.57	17.23	2.25	0.00	0.00	0.00	0.00	0.00	0*	25	8.43
1971/72	ROE-SN	3.04	32.60	38.34	16.05	6.08	2.45	0.93	0.42	0.08	1184	94	276.24*
1972/73	ROE-SN	0.17	40.56	21.55	27.29	8.00	1.68	0.75	0.00	0.00	1726	914	524.51
1973/74	ROE-SN	0.12	30.49	40.38	17.69	9.09	1.86	0.31	0.06	0.00	1617	185	482.78
	ROE-GN	0.00	5.73	48.41	25.48	16.56	3.18	0.00	0.00	0.64	157	25	8.24
1974/75	ROE-SN	0.63	25.31	34.21	27.90	9.53	1.95	0.37	0.10	0.00	6010	655	587.13*
	ROE-GN	0.00	0.00	22.50	40.00	30.00	5.00	2.50	0.00	0.00	40	40	6.19
1975/76	ROE-SN	0.43	2.78	37.34	29.38	22.73	6.31	0.96	0.07	0.00	4170	247	813.57*
	ROE-GN	0.00	0.00	0.75	21.80	60.90	14.29	2.26	0.00	0.00	133	186	91.86
1976/77	ROE-SN	0.09	19.57	8.01	29.41	22.95	15.09	4.47	0.40	0.00	3220	1113	801.25*`
1977/78	ROE-SN	0.16	26.18	17.34	9.48	26.18	14.10	5.27	0.97	0.32	1234	1932	620.46
	ROE-GN	0.00	0.61	4.85	11.52	19.39	39.39	20.00	3.64	0.61	165	126	129.55
1978/79	ROE-SN	5.59	4.41	31.57	18.73	21.27	15.10	2.84	0.39	0.10	1020	441	387.56*
	ROE-GN	0.00	0.00	25.13	25.13	25.13	20.10	3.52	0.50	0.50	199	65	128.20
1979/80	ROE-SN	0.50	83.22	4.45	5.37	2.77	1.89	1.15	0.56	0.09	3390	2427	222.15
	ROE-GN	0.00	3.73	4.48	40.09	20.79	22.28	6.93	1.60	0.11	938	1028	74.53
1980/81	ROE-SN	0.18	3.54	84.99	5.40	3.05	1.82	0.71	0.18	0.12	4943	489	331.92*
	ROE-GN	0.00	0.22	74.81	8.29	9.39	4.86	1.88	0.55	0.00	905	339	121.41
1981/82	ROE-SN	0.84	4.46	4.43	84.63	2.42	1.62	0.95	0.53	0.14	3591	1725	185.38*
	ROE-GN	0.00	0.19	3.42	88.21	3.42	2.66	1.14	0.76	0.19	526	341	99.20
1982/83	ROE-SN	4.88	5.23	3.51	6.86	72.87	3.91	1.58	0.91	0.25	1968	1609	317.79*
	ROE-GN	0.00	0.00	1.34	2.81	89.02	3.08	2.54	0.67	0.54	747	637	58.91
1983/84	WINTER	5.91	36.56	2.15	4.30	8.60	39.25	2.15	0.54	0.54	186	186	9.25
	ROE-SN	2.06	35.34	4.90	2.77	10.53	42.85	1.03	0.35	0.16	3104	1554	312.33
	ROE-GN	0.00	2.81	1.28	4.60	8.95	80.05	1.79	0.26	0.26	391	427	34.59
1984/85	ROE-SN	1.32	14.93	31.83	4.05	4.50	11.36	31.47	0.45	0.08	3556	699	311.61*
	ROE-GN	0.00	0.00	15.28	2.08	4.17	11.11	66.67	0.69	0.00	144	83	85.78
1985/86	ROE-SN	0.21	2.83	21.99	40.19	4.04	3.27	8.03	19.12	0.32	4733	2821	157.73
	ROE-GN	0.00	0.00	11.85	50.62	5.43	5.19	10.37	16.05	0.49	405	383	55.79
1986/87	ROE-SN	1.74	10.42	5.85	24.35	37.76	3.84	4.33	5.79	5.91	3281	1144	131.07*
1987/88	ROE-SN	3.64	51.01	7.52	4.77	11.75	14.86	1.37	1.67	3.40	1676	575	2.56*
1988/89	ROE-SN	2.27	17.46	66.35	4.01	1.57	3.90	2.78	0.62	1.04	3563	199	121.30*
1989/90	ROE-SN	0.22	9.64	18.17	60.02	3.94	1.84	3.82	1.70	0.65	5053	409	411.22*
	ROE-GN	0.00	0.46	8.31	43.65	10.16	8.55	17.09	8.55	3.23	433	397	77.90
1990/91	ROE-SN	6.70	4.13	10.66	28.70	38.47	3.69	1.80	3.99	1.86	3387	1964	383.94*
	ROE-GN	0.00	0.00	2.54	21.57	44.42	9.14	6.85	10.41	5.08	394	457	35.85
1991/92	ROE-SN	0.71	38.51	4.93	8.36	12.45	30.73	2.39	0.59	1.33	3228	2333	267.96
1992/93	ROE-SN	0.32	3.45	60.34	4.45	6.06	12.07	11.75	1.16	0.40	3712	304	314.80`
1993/94	ROE-SN	6.15	4.27	5.00	48.40	10.58	10.91	10.83	3.20	0.66	1219	1516	108.79
1994/95	ROE-SN	14.14	16.93	1.92	4.71	39.09	8.73	7.33	4.71	2.44	573	252	1.00-
1995/96	ROE-SN	10.77	53.87	9.31	3.24	3.35	15.59	2.41	1.15	0.31	956	410	1.00-
1996/97	ROE-SN	22.64	26.17	33.41	5.23	1.52	4.44	5.36	0.85	0.37	1643	299	27.99
1997/98	ROE-SN	0.30	53.28	28.17	11.85	2.92	0.69	1.33	1.07	0.39	2329	1450	239.76
1998/99	ROE-SN	3.46	2.20	64.78	17.03	8.09	2.71	0.70	0.47	0.56	2138	1188	312.26
	ROE-GN	0.00	0.67	30.78	22.80	29.12	9.98	2.66	1.33	2.66	601	413	35.99

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	52.0	84.4	106.6	125.9	147.7	156.8	172.1	147.3	183.5
ROE-SN	65.0	95.9	121.6	142.8	161.7	176.2	187.8	197.4	198.4
ROE-GN	0.0	119.8	140.3	150.9	166.9	176.1	188.2	186.0	192.7

* - Age composition from published reports.
~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
* - includes catch from "other" fisheries
` - includes catch from seine roe fisheries
` - includes catch from gillnet fisheries

Appendix Table 1.2. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over *all seasons* for the Prince Rupert District stock assessment region. These data are used for age-structured model analysis.

		PERCENT AT AGE											
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (X 10)
1950/51	WINTER	4.34	18.20	58.50	10.38	5.62	2.65	0.26	0.04	0.02	4682	2200	4953.11
1951/52	WINTER	4.76	8.81	33.67	45.24	6.15	1.03	0.30	0.03	0.00	5922	2508	4390.81
1952/53	WINTER	1.20	38.13	23.04	25.44	11.13	0.99	0.07	0.00	0.00	1419	752	173.50
1953/54	WINTER	2.11	28.35	29.07	24.02	13.22	2.60	0.60	0.04	0.00	2656	891	2522.89
1954/55	WINTER	2.74	4.86	70.29	15.65	5.22	1.06	0.18	0.00	0.00	1131	467	1698.85
1955/56	WINTER	10.04	58.11	9.51	18.95	2.55	0.53	0.18	0.12	0.00	1683	555	1218.10
1956/57	WINTER	11.49	17.76	39.79	13.21	16.04	1.37	0.32	0.03	0.00	3491	515	2827.98
1957/58	WINTER	45.81	30.22	8.03	11.81	1.77	2.36	0.00	0.00	0.00	847	123	644.16
1958/59	WINTER	3.10	56.69	20.85	5.80	9.88	1.72	1.90	0.06	0.00	1741	349	1037.09
1959/60	WINTER	49.14	6.25	28.20	8.89	4.14	2.52	0.67	0.19	0.00	4206	337	2451.31
1960/61	WINTER	9.74	58.33	7.28	18.00	4.35	1.60	0.58	0.12	0.00	4300	763	4815.52
1961/62	WINTER	3.04	30.30	44.66	6.88	9.92	3.41	0.92	0.54	0.33	1845	752	2476.36
1962/63	WINTER	39.30	13.29	18.18	22.05	3.60	2.96	0.50	0.06	0.06	3415	433	4788.66
1963/64	WINTER	3.71	64.94	10.12	10.94	8.85	0.71	0.59	0.12	0.03	3400	1914	3555.87
1964/65	WINTER	5.98	13.57	50.95	8.54	11.01	8.45	1.04	0.33	0.12	3360	459	3649.12
1965/66	WINTER	0.00	5.29	21.38	23.45	16.32	19.08	9.66	3.22	1.61	435	59	1071.96
1966/67	WINTER	57.22	32.21	5.37	1.88	2.70	0.41	0.20	0.00	0.00	0*	25	1218.55
1967/68	WINTER	34.87	39.74	19.40	4.59	0.73	0.26	0.14	0.27	0.00	0*	25	274.98
1968/69	WINTER	30.04	45.04	20.58	3.90	0.18	0.21	0.04	0.00	0.00	0*	25	69.11
1969/70	WINTER	18.67	62.91	15.11	3.12	0.03	0.08	0.08	0.00	0.00	0*	25	183.69
1970/71	WINTER	6.49	50.42	29.28	7.99	4.33	0.83	0.50	0.17	0.00	601	38	413.67
1971/72	ROE-SN	0.00	5.32	17.93	64.43	5.88	3.78	2.38	0.14	0.14	714	209	278.66*`
1972/73	ROE-SN	0.25	33.00	4.39	30.36	26.60	3.39	1.25	0.75	0.00	797	662	109.21*
1973/74	ROE-SN	0.16	17.88	53.16	7.44	16.46	4.43	0.32	0.16	0.00	632	121	174.36*
	ROE-GN	0.00	0.96	39.42	21.15	34.62	2.88	0.96	0.00	0.00	104	83	90.07
1974/75	ROE-SN	1.30	9.40	22.19	43.10	11.16	9.63	2.47	0.59	0.16	3074	778	127.95*
	ROE-GN	0.00	0.00	31.91	59.57	8.51	0.00	0.00	0.00	0.00	47	47	0.76
1975/76	ROE-SN	0.00	0.84	6.87	31.70	50.07	7.29	2.38	0.84	0.00	713	654	237.22*
	ROE-GN	0.00	0.00	15.79	57.89	22.81	3.51	0.00	0.00	0.00	57	57	17.93
1976/77	ROE-SN	0.08	16.03	3.74	22.67	37.79	15.04	3.28	0.92	0.46	1310	1344	420.46*
	ROE-GN	0.00	1.07	2.14	19.93	54.09	14.59	6.76	1.42	0.00	281	1104	89.48
1977/78	ROE-SN	1.13	11.70	32.83	9.56	21.13	20.38	2.39	0.63	0.25	795	131	373.38*
	ROE-GN	0.00	0.00	20.53	5.96	32.85	33.11	6.62	1.32	0.00	151	37	181.42
1978/79	ROE-SN	2.71	18.16	11.48	29.23	11.48	18.27	6.47	1.36	0.84	958	1475	204.57*
	ROE-GN	1.15	1.15	8.05	41.38	15.71	22.22	8.05	1.92	0.38	261	255	74.00
1979/80	ROE-SN	0.64	77.94	7.26	5.09	3.81	3.49	1.28	0.39	0.11	2811	535	249.07*
	ROE-GN	0.00	3.45	8.72	31.24	22.31	21.10	9.13	3.45	0.61	493	915	63.73
1980/81	ROE-SN	0.46	11.18	81.22	3.30	1.73	1.51	0.37	0.15	0.06	3238	1059	275.60*
	ROE-GN	0.00	0.47	38.88	15.46	22.95	14.75	5.62	1.87	0.00	427	557	23.77
1981/82	ROE-SN	2.72	18.78	7.38	66.32	2.85	1.36	0.39	0.19	0.00	1544	576	193.03*
1982/83	ROE-SN	1.35	20.82	17.74	5.26	49.16	3.73	1.13	0.59	0.22	4583	1448	1.00-
1983/84	ROE-SN	0.49	35.46	14.42	10.29	14.38	23.62	0.99	0.25	0.11	2837	618	175.68*
	ROE-GN	0.00	0.99	1.98	12.87	21.39	57.43	3.37	1.19	0.79	505	961	127.31
1984/85	ROE-SN	0.22	7.75	54.69	11.93	6.39	10.56	8.19	0.14	0.14	3664	969	301.45*
	ROE-GN	0.00	0.36	16.36	14.91	15.82	21.82	29.82	0.36	0.55	550	543	235.00
1985/86	ROE-SN	1.75	13.76	9.44	46.26	10.80	5.27	7.09	5.53	0.09	5655	4566	305.47*
	ROE-GN	0.00	0.39	4.32	53.85	19.00	8.71	7.77	5.73	0.24	1274	558	311.02
1986/87	ROE-SN	0.89	38.64	10.21	6.89	29.87	5.90	3.49	2.87	1.25	4731	4068	187.95*
	ROE-GN	0.00	0.57	3.01	6.93	55.25	16.07	8.80	5.96	3.41	1761	819	270.57
1987/88	ROE-SN	0.45	30.94	39.00	5.95	8.34	11.56	1.94	1.45	0.38	4221	2992	353.54*
	ROE-GN	0.00	0.42	6.48	7.18	21.55	44.79	11.69	5.07	2.82	710	421	276.81
1988/89	ROE-SN	0.61	21.68	36.14	27.68	4.92	4.48	3.57	0.64	0.28	3616	1265	357.83*
	ROE-GN	0.00	0.00	4.62	30.46	13.66	23.53	21.85	3.36	2.52	476	432	317.93
1989/90	ROE-SN	0.65	18.15	22.55	28.24	20.52	4.01	3.31	2.15	0.41	5068	3572	194.38*
	ROE-GN	0.00	0.00	6.25	21.32	42.46	10.29	11.58	6.07	2.02	544	180	161.00
1990/91	ROE-SN	0.95	48.03	9.49	12.60	15.75	9.49	1.65	0.87	1.17	4120	2451	214.06*
	ROE-GN	0.00	0.00	4.26	18.67	31.44	31.33	6.66	4.37	3.28	916	502	148.32
1991/92	ROE-SN	0.35	39.84	37.21	5.89	5.35	6.73	3.42	0.61	0.61	4265	529	228.23*
	ROE-GN	0.00	0.35	13.08	9.35	22.78	26.29	19.16	3.97	5.02	856	114	260.14
1992/93	ROE-SN	0.12	10.73	44.28	30.20	4.02	4.40	4.35	1.56	0.35	4027	372	293.46*
	ROE-GN	0.00	0.00	8.32	40.54	9.53	18.52	13.29	8.19	1.61	745	666	306.61
1993/94	ROE-SN	0.68	4.88	13.36	48.68	22.64	4.12	3.68	1.42	0.54	6459	1430	287.05*
	ROE-GN	0.00	0.00	2.38	17.62	47.55	12.73	11.19	6.43	2.10	715	760	174.03
1994/95	ROE-SN	3.19	15.32	6.76	11.27	43.21	15.75	2.44	1.27	0.80	4393	2013	136.57
	ROE-GN	0.00	0.12	1.18	16.98	34.79	39.39	4.13	1.89	1.53	848	1013	103.11
1995/96	ROE-SN	1.09	64.00	9.79	3.17	4.61	11.06	5.70	0.35	0.23	1736	1241	122.25
	ROE-GN	0.00	0.78	4.11	5.68	25.83	32.68	26.42	3.13	1.37	511	171	230.53
1996/97	ROE-SN	0.94	18.40	56.15	8.59	3.10	5.40	5.07	2.11	0.23	2130	489	110.79
	ROE-GN	0.00	0.16	19.49	11.57	13.95	20.29	20.60	11.09	2.85	631	568	415.50
1997/98	ROE-SN	0.19	33.18	21.98	36.29	4.44	1.42	1.09	1.28	0.14	2116	1270	120.37
	ROE-GN	0.00	0.65	3.05	43.07	20.52	9.89	11.28	7.02	4.53	1082	851	251.59
1998/99	ROE-SN	0.99	5.52	41.05	20.35	24.71	4.42	1.05	0.87	1.05	1720	305	121.60
	ROE-GN	0.00	0.00	10.82	16.50	49.51	13.45	4.58	1.94	3.19	721	331	147.57

AVERAGE WEIGHT AT AGE (gms)

FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	40.6	79.0	107.8	128.1	145.3	161.4	172.0	181.5	194.1
ROE-SN	52.4	80.7	106.9	128.2	145.0	158.1	170.3	179.3	188.9
ROE-GN	90.3	114.6	130.0	139.6	149.8	156.1	163.1	170.0	175.6

* - Age composition from published reports.
\- - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
* - includes catch from "other" fisheries
^ - includes catch from seine roe fisheries
` - includes catch from gillnet fisheries

Appendix Table 1.3. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Central Coast stock assessment region. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
1950/51	WINTER	2.43	28.56	50.66	12.00	5.06	1.24	0.06	0.00	0.00	5316	2487	3904.06
1951/52	WINTER	5.18	20.07	30.08	38.13	4.50	1.53	0.45	0.04	0.02	5156	1431	2925.93
1952/53	WINTER	9.36	28.09	23.99	26.62	10.15	1.33	0.44	0.00	0.00	2926	543	73.57
1953/54	WINTER	3.95	69.68	20.26	4.61	1.29	0.16	0.00	0.06	0.00	3189	478	3476.95
1954/55	WINTER	6.66	7.72	74.62	9.09	1.54	0.38	0.00	0.00	0.00	2344	165	1235.03
1955/56	WINTER	16.88	13.62	9.20	57.01	2.89	0.34	0.04	0.00	0.02	5052	1347	4134.75
1956/57	WINTER	16.74	50.70	10.79	6.23	14.78	0.73	0.02	0.00	0.00	4688	1703	2635.45
1957/58	WINTER	23.51	61.39	12.66	1.28	0.59	0.56	0.00	0.00	0.00	3743	847	1445.86
1958/59	WINTER	3.80	49.52	36.89	8.10	0.80	0.44	0.42	0.02	0.00	4974	1352	3293.36
1959/60	WINTER	43.50	23.16	26.48	5.58	1.13	0.07	0.07	0.00	0.00	1416	165	639.45
1960/61	WINTER	16.08	32.23	10.79	29.69	10.08	0.93	0.11	0.07	0.04	2799	1227	3463.55
1961/62	WINTER	9.65	57.43	17.95	2.60	9.90	2.35	0.12	0.00	0.00	808	146	1721.99
1962/63	WINTER	0.37	30.27	57.96	5.43	2.85	2.94	0.18	0.00	0.00	1087	885	4376.33
1963/64	WINTER	13.12	47.38	27.74	10.25	1.43	0.08	0.00	0.00	0.00	1258	198	3507.73
1964/65	WINTER	8.17	36.40	33.77	15.83	5.43	0.34	0.06	0.00	0.00	1750	684	1326.51
1965/66	WINTER	67.32	20.43	7.33	3.60	1.13	0.19	0.00	0.00	0.00	0*	25	5216.79
1966/67	WINTER	37.40	46.19	13.10	2.04	1.02	0.17	0.07	0.01	0.00	0*	25	2514.89
1967/68	WINTER	32.53	48.02	17.02	2.11	0.25	0.00	0.06	0.00	0.00	0*	25	170.14
1968/69	WINTER	32.21	27.70	26.72	11.30	1.95	0.12	0.00	0.00	0.00	0*	25	10.08
1969/70	WINTER	54.02	44.42	1.16	0.40	0.00	0.00	0.00	0.00	0.00	0*	25	28.32
1970/71	WINTER	14.39	39.60	36.87	3.78	4.20	0.95	0.11	0.11	0.00	952	136	339.30
1971/72	ROE-SN	4.35	29.83	27.65	25.69	6.91	4.35	1.14	0.05	0.00	1837	598	762.73*
	ROE GN	0.00	0.91	14.89	65.05	10.64	7.90	0.61	0.00	0.00	329	503	8.47
1972/73	ROE-SN	1.20	50.45	18.60	15.51	11.75	1.88	0.45	0.15	0.00	1328	593	539.55*
	ROE-GN	0.00	2.53	25.32	44.94	20.89	4.43	1.27	0.63	0.00	158	114	71.26
1973/74	ROE-SN	2.77	17.71	38.63	19.72	13.36	6.62	0.95	0.25	0.00	1587	202	282.57
	ROE-GN	0.00	0.40	22.78	37.70	24.80	12.30	1.81	0.20	0.00	496	101	332.81
1974/75	ROE-SN	1.16	32.96	25.51	27.84	8.59	3.18	0.67	0.07	0.02	8896	3314	278.00
	ROE-GN	0.00	3.28	25.63	46.24	16.38	6.36	2.12	0.00	0.00	519	117	348.42
1975/76	ROE-SN	3.01	11.76	41.23	20.89	16.83	4.54	1.48	0.24	0.02	5418	973	511.14
	ROE-GN	0.00	0.82	18.82	29.79	35.27	11.78	3.03	0.41	0.08	1222	253	383.45
1976/77	WINTER	1.01	32.83	18.69	29.80	8.08	6.57	3.03	0.00	0.00	198	144	32.75
	ROE-SN	0.68	17.43	22.64	31.77	16.59	8.53	1.92	0.40	0.04	2496	925	284.27
	ROE-GN	0.00	1.10	13.02	35.54	31.57	13.47	3.97	1.32	0.00	453	169	411.71
1977/78	ROE-SN	0.21	25.72	15.19	19.91	23.14	10.89	3.51	1.07	0.36	1395	589	354.31
	ROE-GN	0.00	1.30	8.93	29.58	36.14	17.67	3.81	0.47	0.09	1075	474	576.00
1979/80	ROE-SN	3.68	73.08	6.43	9.02	3.99	2.59	0.70	0.39	0.12	2582	1401	1.12*
	ROE-GN	0.00	3.28	2.55	24.82	23.72	26.28	11.31	6.57	1.46	274	210	32.46
1980/81	ROE-SN	1.96	12.30	66.57	8.40	7.05	2.64	0.64	0.34	0.10	2952	492	25.75*
	ROE-GN	0.26	1.50	50.72	13.61	15.36	10.61	5.47	1.82	0.65	1536	276	163.04
1981/82	ROE-SN	1.68	15.62	10.72	60.21	5.19	4.56	1.45	0.48	0.09	3508	2296	188.15*
	ROE-GN	0.00	2.39	5.91	75.99	6.66	5.91	2.12	0.75	0.07	1337	301	287.08
1982/83	ROE-SN	0.53	7.00	15.43	10.82	57.10	5.03	3.10	0.73	0.26	5445	1082	154.75
	ROE-GN	0.00	0.50	7.19	13.05	69.44	5.02	3.90	0.61	0.28	1793	994	244.49
1983/84	ROE-SN	4.35	7.31	10.12	18.16	16.14	40.73	2.26	0.83	0.10	6293	2210	282.42*
	ROE-GN	0.00	0.26	2.93	13.11	17.26	60.05	4.75	1.12	0.52	1159	338	242.25
1984/85	ROE-SN	2.66	37.54	7.47	8.55	13.11	11.94	18.19	0.45	0.10	5157	6529	222.13
	ROE-GN	0.00	3.18	5.43	9.39	19.49	22.52	38.20	1.01	0.78	1288	1407	143.53
1985/86	ROE-SN	3.92	16.39	40.25	8.59	6.27	6.68	6.08	11.26	0.55	5819	2074	163.81*
	ROE-GN	0.00	1.78	23.95	11.97	10.01	16.00	13.19	22.26	0.84	1069	262	73.95
1986/87	ROE-SN	4.13	22.57	14.59	32.18	5.72	4.55	5.84	4.66	5.78	5038	2319	193.73
	ROE-GN	0.00	0.82	7.75	44.85	11.72	7.85	9.89	8.15	8.97	981	1199	55.71
1987/88	ROE-SN	1.14	67.92	11.67	6.28	7.12	1.68	1.46	1.50	1.23	5194	2730	343.88*
	ROE-GN	0.00	4.24	10.25	14.84	27.21	15.19	7.42	10.07	10.78	566	158	59.82
1988/89	ROE-SN	1.28	4.61	76.21	9.16	3.58	2.80	0.74	0.60	0.82	5642	1939	596.24
	ROE-GN	0.00	0.28	27.61	25.07	17.32	16.48	5.77	3.66	3.80	710	259	195.14
1989/90	ROE-SN	0.97	5.66	4.99	72.59	7.49	3.82	2.95	0.75	0.78	6677	6353	415.05
	ROE-GN	0.00	0.00	1.18	65.05	16.88	6.26	7.79	1.06	1.77	847	502	203.56
1990/91	ROE-SN	2.03	18.82	6.76	6.19	55.55	6.38	2.34	1.48	0.46	7105	5044	541.68
	ROE-GN	0.00	0.50	2.32	6.80	69.15	9.95	7.30	3.15	0.83	603	423	116.55
1991/92	ROE-SN	2.01	58.38	11.40	2.74	3.44	18.75	2.13	0.61	0.54	7264	4356	722.92*
	ROE-GN	0.00	6.92	6.92	4.23	6.54	60.90	9.74	3.33	1.41	780	544	69.73
1992/93	ROE-SN	2.85	6.71	64.15	9.68	2.02	2.55	10.46	1.12	0.46	8664	3221	784.75
	ROE-GN	0.00	0.26	43.79	14.34	5.63	5.76	27.02	2.18	1.02	781	188	146.71
1993/94	ROE-SN	1.19	21.29	8.52	52.95	7.48	2.01	2.76	3.48	0.32	7127	4910	875.10
	ROE-GN	0.00	1.47	4.95	65.08	12.66	3.36	4.42	7.18	0.88	1698	838	158.40
1994/95	ROE-SN	0.75	6.06	23.16	9.44	48.04	6.46	2.01	2.31	1.76	9148	4236	700.37
	ROE-GN	0.00	0.22	9.37	8.11	64.45	10.25	2.06	2.36	3.17	1356	746	105.27
1995/96	ROE-SN	11.63	19.56	5.81	16.70	6.81	30.61	5.96	1.49	1.43	5316	3344	398.77
	ROE-GN	0.00	0.35	1.41	18.02	11.48	54.06	10.42	2.12	2.12	566	175	27.42
1996/97	ROE-SN	2.13	56.65	16.83	3.62	6.14	3.99	8.49	1.54	0.55	6870	3214	451.35
	ROE-GN	0.00	1.36	2.92	6.23	22.76	19.26	38.33	7.20	1.95	514	477	24.01
1997/98	ROE-SN	0.52	35.84	42.09	8.55	2.45	3.20	3.23	3.29	0.82	6562	3475	1016.41
	ROE-GN	0.00	0.53	13.91	13.69	8.81	18.58	15.82	20.49	8.17	942	188	45.06
1998/99	ROE-SN	0.71	8.76	42.66	34.27	6.52	1.66	2.18	1.95	1.29	4815	1683	711.07
	ROE-GN	0.00	0.11	14.24	44.88	17.91	6.69	5.50	6.15	4.53	927	411	116.52

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	43.8	79.8	104.7	125.6	138.1	150.4	156.2	153.5	179.0
ROE-SN	53.4	85.2	109.4	129.7	147.0	162.0	174.6	185.6	193.9
ROE-GN	39.3	114.4	133.7	144.8	154.2	163.6	171.7	177.1	176.4

* - Age composition from published reports.
~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
¶ - includes catch from "other" fisheries
^ - includes catch from seine roe fisheries
` - includes catch from gillnet fisheries

Appendix Table 1.4. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the Strait of Georgia stock assessment region. These data are used for age-structured model analysis.

		PERCENT AT AGE									NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
1950/51	WINTER	4.17	56.48	30.35	7.12	1.41	0.35	0.10	0.03	0.00	7813	1085	4404.07
1951/52	WINTER	11.17	55.37	25.06	6.74	1.32	0.27	0.07	0.01	0.00	9025	1541	4821.55
1952/53	WINTER	9.47	56.02	28.96	4.09	1.23	0.20	0.05	0.00	0.00	8640	1489	1038.41
1953/54	WINTER	1.52	45.67	36.81	11.55	3.28	0.94	0.21	0.02	0.00	13162	4357	6463.55
1954/55	WINTER	4.40	48.63	39.05	6.73	1.08	0.11	0.00	0.00	0.00	5291	805	7070.11
1955/56	WINTER	7.00	35.08	28.78	23.67	4.45	0.73	0.21	0.05	0.02	9832	2632	7200.60
1956/57	WINTER	1.40	59.78	22.33	10.70	5.08	0.60	0.07	0.01	0.03	7478	2184	5972.40
1957/58	WINTER	8.98	54.48	22.13	5.99	5.06	2.89	0.41	0.07	0.00	7397	1589	2238.02
1958/59	WINTER	17.11	63.89	15.48	2.58	0.55	0.24	0.12	0.02	0.01	9964	3899	6104.01
1959/60	WINTER	7.70	51.34	36.56	3.61	0.53	0.16	0.08	0.00	0.03	3742	1215	6919.14
1960/61	WINTER	31.53	27.21	26.87	12.73	1.49	0.16	0.00	0.00	0.00	4351	820	5244.59
1961/62	WINTER	9.05	70.06	13.18	5.28	2.03	0.37	0.03	0.00	0.00	3203	936	7130.68
1962/63	WINTER	17.63	50.93	26.85	2.99	1.00	0.52	0.09	0.00	0.00	2309	403	8123.36
1963/64	WINTER	5.94	60.95	29.88	2.56	0.52	0.10	0.05	0.00	0.00	4026	1190	7537.03
1964/65	WINTER	14.90	55.13	26.15	2.54	0.96	0.18	0.15	0.00	0.00	3350	910	4622.10
1965/66	WINTER	25.15	34.78	23.38	13.51	2.12	1.06	0.00	0.00	0.00	851	98	3229.67
1966/67	WINTER	36.90	45.72	12.18	3.21	1.59	0.29	0.05	0.06	0.00	0*	25	3307.57
1967/68	WINTER	30.37	50.62	14.68	3.04	0.88	0.18	0.23	0.00	0.00	0*	25	199.84
1968/69	WINTER	62.04	27.10	8.08	2.06	0.72	0.00	0.00	0.00	0.00	0*	25	95.62
1969/70	WINTER	25.64	60.32	9.49	3.27	0.72	0.56	0.00	0.00	0.00	0*	25	89.93
1970/71	WINTER	12.38	40.17	36.49	7.14	2.83	0.92	0.07	0.00	0.00	1414	370	147.08
1971/72	WINTER	10.32	31.86	34.62	18.21	3.49	1.34	0.14	0.03	0.00	3663	1460	229.07
	ROE-SN	8.50	36.12	32.86	17.93	3.46	0.99	0.12	0.02	0.00	5036	766	545.88
	ROE-GN	4.44	11.50	46.47	28.99	6.86	1.45	0.19	0.10	0.00	1035	251	9.76
1972/73	WINTER	1.00	27.94	31.02	25.45	12.51	1.74	0.30	0.04	0.00	4707	1573	295.59
	ROE-SN	4.22	54.88	21.37	12.93	6.07	0.53	0.00	0.00	0.00	379	615	141.70
	ROE-GN	0.00	17.41	30.36	37.50	11.16	3.13	0.45	0.00	0.00	224	106	136.90
1973/74	WINTER	17.44	73.26	8.14	1.16	0.00	0.00	0.00	0.00	0.00	86	86	112.05^
	ROE-GN	0.00	4.85	42.22	31.31	16.67	4.04	0.91	0.00	0.00	990	548	196.73
1974/75	WINTER	22.35	61.06	12.44	2.07	1.38	0.46	0.00	0.23	0.00	434	16	70.07
	ROE-SN	3.68	54.91	27.96	7.86	3.35	1.60	0.48	0.17	0.00	5194	1210	46.28
	ROE-GN	0.00	4.97	43.09	35.91	12.15	3.31	0.55	0.00	0.00	181	20	351.18
1975/76	WINTER	6.25	20.45	41.35	21.52	6.27	2.77	0.93	0.41	0.05	4401	1271	401.26
	ROE-SN	12.02	24.84	40.61	14.78	3.38	2.32	1.51	0.45	0.09	1123	164	20.37
	ROE-GN	0.00	0.57	39.48	43.55	12.67	2.94	0.68	0.11	0.00	884	354	468.85
1976/77	WINTER	4.15	50.85	22.01	16.55	4.45	1.24	0.49	0.15	0.11	2653	911	518.05
	ROE-SN	3.35	55.79	20.11	14.47	3.86	1.27	0.76	0.25	0.13	2357	1054	394.81
	ROE-GN	0.00	3.38	28.54	47.25	16.46	3.75	0.50	0.13	0.00	1598	147	514.34
1977/78	WINTER	2.31	36.01	40.47	10.34	7.42	2.64	0.41	0.28	0.12	2466	380	1182.89
	ROE-SN	0.85	35.31	43.14	11.57	7.39	1.37	0.29	0.03	0.06	3424	2450	354.62
	ROE-GN	0.00	0.71	20.32	30.04	35.69	11.48	1.41	0.35	0.00	566	1022	485.32
1978/79	WINTER	1.76	18.25	37.65	28.52	8.38	3.95	1.08	0.27	0.13	5463	1858	1085.01
	ROE-SN	1.63	20.01	32.72	27.96	9.37	5.18	2.06	0.64	0.43	1409	389	1.00~
	ROE-GN	0.00	1.15	23.23	54.70	15.51	5.77	1.48	0.00	0.16	607	290	441.60
1979/80	WINTER	2.99	43.51	23.26	18.15	8.30	2.16	1.24	0.31	0.08	4914	3044	228.46
	ROE-SN	2.49	49.82	15.90	17.71	9.86	2.61	1.23	0.27	0.12	4139	1495	16.94
	ROE-GN	0.00	1.99	9.15	44.56	33.42	8.75	1.86	0.27	0.00	754	1139	215.21
1980/81	WINTER	3.66	34.26	34.21	15.60	8.57	3.02	0.52	0.16	0.00	5160	2376	421.38
	ROE-SN	6.92	36.99	30.47	11.33	9.61	3.73	0.63	0.28	0.03	7731	2525	202.00
	ROE-GN	0.09	2.19	18.16	22.98	37.37	16.05	2.81	0.26	0.09	1140	338	133.10
1981/82	WINTER	3.36	38.13	31.72	16.14	5.74	3.80	0.91	0.08	0.12	2528	1506	316.45
	ROE-SN	6.31	34.70	25.07	20.87	4.69	5.22	2.50	0.56	0.07	5400	2796	313.69
	ROE-GN	0.00	4.44	15.37	28.45	14.77	20.77	14.17	1.68	0.36	833	543	367.36
1982/83	WINTER	3.06	19.28	30.43	21.91	12.30	4.45	5.26	2.78	0.53	2090	1037	58.60
	ROE-SN	2.99	31.42	28.48	17.84	11.47	3.19	3.06	1.25	0.29	11962	7026	696.76
	ROE-GN	0.00	0.49	27.76	29.48	23.59	9.34	7.37	1.72	0.25	407	305	563.81
1983/84	WINTER	14.62	31.77	23.11	17.06	8.33	3.35	1.01	0.43	0.32	1882	581	70.14
	ROE-SN	8.08	37.75	28.97	12.93	7.16	3.33	1.13	0.49	0.15	7152	1852	392.25
	ROE-GN	0.00	7.05	30.16	31.07	19.19	9.27	1.70	0.65	0.91	766	759	421.50
1984/85	WINTER	27.95	40.76	19.11	7.61	3.09	1.03	0.36	0.08	0.00	2522	507	77.78
	ROE-SN	23.91	43.83	18.95	7.92	3.40	1.33	0.59	0.06	0.01	7832	3009	297.73
	ROE-GN	0.09	3.10	26.09	32.48	23.63	9.22	3.74	0.82	0.82	1096	650	237.16
1985/86	WINTER	13.44	58.05	20.53	5.79	1.74	0.35	0.12	0.00	0.00	863	185	40.18
	ROE-SN	12.56	56.18	22.20	6.18	1.92	0.75	0.14	0.08	0.00	6411	1413	17.24
1986/87	WINTER	21.77	34.69	30.95	9.98	1.93	0.45	0.23	0.00	0.00	882	204	22.53
	ROE-SN	9.34	33.15	37.03	15.29	3.55	1.07	0.38	0.13	0.07	7689	2111	318.01
	ROE_GN	0.00	2.50	35.63	33.44	16.51	8.49	2.60	0.57	0.26	1920	944	413.31
1987/88	WINTER	3.50	60.18	17.29	15.32	2.74	0.66	0.22	0.11	0.00	914	1104	69.17
	ROE-SN	4.38	60.06	14.92	15.22	4.09	1.03	0.22	0.07	0.00	5912	1835	148.13
	ROE-GN	0.00	9.14	14.86	48.11	19.49	5.48	2.31	0.37	0.24	821	383	414.24
1988/89	WINTER	26.50	16.59	42.90	7.05	5.91	0.86	0.19	0.00	0.00	1049	298	93.71
	ROE-SN	10.01	18.01	53.48	9.45	7.10	1.59	0.31	0.03	0.02	6423	1619	140.64
	ROE-GN	0.00	1.58	40.22	21.99	25.88	7.78	2.19	0.36	0.00	823	1143	421.70
1989/90	WINTER	4.97	57.32	13.69	19.33	2.15	2.55	0.00	0.00	0.00	745	323	22.74
	ROE-SN	7.92	57.18	10.74	18.98	3.01	1.72	0.41	0.05	0.02	5644	2499	1.00~
	ROE-GN	0.00	8.39	11.67	56.24	12.18	9.70	1.46	0.29	0.07	1371	815	556.90
1990/91	WINTER	18.35	32.39	35.45	6.46	6.34	0.79	0.23	0.00	0.00	883	439	54.37
	ROE-SN	9.42	21.74	40.64	9.20	15.06	2.27	1.45	0.20	0.02	5106	1604	103.87
	ROE-GN	0.00	1.29	28.15	17.20	40.11	7.27	4.69	1.20	0.09	1087	637	644.61
1991/92	WINTER	3.96	69.60	16.30	9.03	0.66	0.22	0.22	0.00	0.00	454	143	91.46
	ROE-SN	5.10	54.85	13.72	16.74	3.49	5.16	0.60	0.32	0.02	5026	4330	346.46
	ROE-GN	0.00	6.63	14.88	43.63	11.72	18.91	2.65	1.45	0.43	1169	865	600.81
1992/93	WINTER	25.90	31.04	32.48	6.89	2.67	0.31	0.62	0.10	0.00	973	75	62.36
	ROE-SN	15.17	37.83	31.39	6.87	5.75	1.36	1.45	0.15	0.04	5445	1959	440.36
	ROE-GN	0.00	11.47	40.02	16.98	21.61	4.08	5.40	0.22	0.22	907	562	633.26
1993/94	WINTER	5.65	50.00	25.43	16.30	1.52	1.09	0.00	0.00	0.00	460	142	92.93
	ROE-SN	4.67	42.19	26.71	18.77	3.99	2.82	0.70	0.15	0.00	5968	3788	528.54
	ROE-GN	0.00	3.53	25.10	44.92	15.20	7.98	2.43	0.67	0.17	1191	703	865.23
1994/95	WINTER	22.08	27.18	34.32	10.90	4.46	0.71	0.28	0.00	0.07	1413	360	63.14
	ROE-SN	8.98	21.79	36.13	17.73	11.08	2.74	1.10	0.35	0.11	5658	3092	397.08
	ROE-GN	0.00	2.27	26.21	36.79	26.11	5.61	2.37	0.43	0.22	927	340	586.53
1995/96	WINTER	25.36	49.46	11.99	9.46	2.47	1.08	0.18	0.00	0.00	1660	473	62.22
	ROE-SN	12.98	48.36	14.05	14.43	5.80	3.38	0.69	0.23	0.08	8296	4663	759.67
	ROE-GN	0.00	3.86	15.81	45.40	21.88	10.29	1.84	0.74	0.18	544	452	449.47
1996/97	ROE-SN	0.94	18.40	56.15	8.59	3.10	5.40	5.07	2.11	0.23	2130	489	110.79
	ROE-GN	0.00	0.16	19.49	11.57	13.95	20.29	20.60	11.09	2.85	631	568	415.50
1997/98	ROE-SN	0.19	33.18	21.98	36.29	4.44	1.42	1.09	1.28	0.14	2116	1270	120.37
	ROE-GN	0.00	0.65	3.05	43.07	20.52	9.89	11.28	7.02	4.53	1082	851	251.59
1998/99	WINTER	11.79	28.03	41.71	14.62	3.10	0.61	0.13	0.00	0.00	1484	117	161.58
	ROE-SN	6.18	24.63	41.42	18.55	6.53	1.78	0.70	0.15	0.05	3979	1113	518.40
	ROE-GN	0.00	2.15	29.31	36.72	21.05	6.70	3.35	0.60	0.12	836	338	522.51

	AVERAGE WEIGHT AT AGE (gms)								
FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	54.5	90.1	115.1	138.1	152.5	166.5	177.4	185.6	203.0
ROE-SN	57.6	83.5	108.6	128.8	147.1	161.5	170.8	177.9	188.8
ROE-GN	66.2	117.7	133.9	144.5	154.3	161.6	171.2	169.5	172.3

* - Age composition from published reports.
~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
" -includes catch from "other" fisheries
^ - includes catch from seine roe fisheries
` -includes catch from gillnet fisheries

Appendix Table 1.5. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for the west coast of Vancouver Island stock assessment region. These data are used for age-structured model analysis.

		PERCENT AT AGE									NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
1950/51	WINTER	12.58	37.63	41.27	6.74	1.44	0.30	0.02	0.02	0.00	4037	680	2223.54
1951/52	WINTER	1.97	29.16	24.99	37.07	4.96	1.46	0.33	0.04	0.00	4921	2483	2287.45
1952/53	WINTER	14.28	56.10	27.45	1.64	0.48	0.05	0.00	0.00	0.00	2357	607	2.46
1953/54	WINTER	2.68	63.23	27.59	5.55	0.69	0.15	0.08	0.02	0.02	6092	1607	3570.83
1954/55	WINTER	16.82	59.39	19.69	3.43	0.64	0.04	0.00	0.00	0.00	2509	698	715.69
1955/56	WINTER	10.00	58.10	9.50	19.00	2.60	0.50	0.20	0.10	0.00	0*	25	1751.84
1956/57	WINTER	2.72	71.94	24.83	0.34	0.17	0.00	0.00	0.00	0.00	588	497	314.44
1957/58	WINTER	12.94	48.66	27.06	6.30	2.86	1.68	0.42	0.08	0.00	1190	344	69.90
1958/59	WINTER	4.23	45.02	27.39	14.41	5.85	2.40	2.02	0.57	0.11	3665	2199	7436.55
1959/60	WINTER	8.86	54.74	23.32	8.76	2.82	0.94	0.35	0.14	0.07	2877	2160	5631.14
1960/61	WINTER	41.08	37.18	17.69	3.90	0.15	0.00	0.00	0.00	0.00	667	84	3143.83
1961/62	WINTER	4.68	81.76	10.31	2.46	0.79	0.00	0.00	0.00	0.00	1261	551	2543.14
1962/63	WINTER	1.73	43.62	49.16	4.69	0.62	0.18	0.00	0.00	0.00	2258	893	1779.64
1963/64	WINTER	2.53	60.22	25.76	10.39	0.84	0.25	0.00	0.00	0.00	1184	1057	2078.97
1964/65	WINTER	2.18	34.34	49.88	9.95	3.28	0.36	0.00	0.00	0.00	824	372	1302.20
1965/66	WINTER	13.59	26.83	26.12	23.17	9.07	1.23	0.00	0.00	0.00	0*	25	791.48
1966/67	WINTER	12.86	60.28	20.52	4.84	1.15	0.18	0.15	0.02	0.00	0*	25	1289.24
1971/72	ROE-SN	3.25	18.52	48.12	24.63	3.50	1.15	0.76	0.06	0.00	1571	650	503.52
1972/73	ROE-SN	0.70	30.43	24.26	31.95	10.75	1.55	0.27	0.08	0.00	2576	1744	1204.92
	ROE-GN	0.00	7.85	22.92	51.76	13.46	2.88	0.96	0.16	0.00	624	526	95.73
1973/74	ROE-SN	8.04	43.04	23.95	13.62	8.86	2.21	0.22	0.04	0.02	5420	3103	1112.16
	ROE-GN	0.00	26.14	30.68	26.14	13.64	3.41	0.00	0.00	0.00	176	30	288.53
1974/75	ROE-SN	0.59	53.76	19.82	11.40	7.97	4.99	1.29	0.17	0.01	10114	4380	1451.92*
	ROE-GN	0.00	2.97	30.48	37.92	21.19	7.06	0.37	0.00	0.00	269	145	493.67
1975/76	ROE-SN	0.21	8.86	46.93	19.80	12.96	8.08	2.72	0.43	0.00	9230	1628	1626.81
	ROE-GN	0.00	0.68	40.26	33.87	15.68	6.62	2.51	0.30	0.08	1314	127	1053.75
1976/77	ROE-SN	0.52	12.42	31.09	37.16	12.36	4.46	1.66	0.28	0.04	6746	1395	1281.46*
	ROE-GN	0.56	3.35	16.48	42.74	17.60	12.29	5.31	1.40	0.28	358	49	813.02
1977/78	WINTER	1.27	43.83	23.50	13.70	14.21	2.16	0.81	0.30	0.21	2357	521	257.67
	ROE-SN	0.69	40.18	17.88	16.77	18.51	4.43	1.29	0.18	0.07	5963	2622	457.42
	ROE-GN	0.00	1.16	4.46	20.66	46.94	19.17	6.61	0.66	0.33	605	168	936.91
1978/79	ROE-SN	0.77	13.64	50.60	14.26	10.66	7.88	1.54	0.51	0.13	3885	564	849.26*
	ROE-GN	0.00	1.23	25.92	26.62	25.04	18.91	1.93	0.35	0.00	571	257	519.39
1979/80	ROE-SN	2.86	43.86	14.95	22.01	7.26	6.06	2.43	0.47	0.10	3003	469	152.30*
	ROE-GN	0.00	0.00	5.31	47.12	22.57	14.38	9.73	0.66	0.22	452	497	145.27
1980/81	ROE-SN	3.36	34.58	29.40	11.00	12.95	5.79	2.40	0.51	0.00	3745	853	433.90*
	ROE-GN	0.00	1.78	21.00	14.95	36.30	18.86	7.12	0.00	0.00	281	81	207.25
1981/82	ROE-SN	3.17	23.98	27.76	26.08	5.45	9.24	2.62	1.41	0.30	5046	2597	204.20*
	ROE-GN	0.00	0.58	11.94	43.34	11.70	27.11	4.06	1.26	0.12	663	365	221.31
1982/83	ROE-SN	4.21	22.56	21.87	21.90	17.66	4.43	5.40	1.06	0.90	3205	1818	477.79
	ROE-GN	0.00	0.35	14.19	23.82	44.83	6.48	9.81	0.35	0.18	571	159	176.62
1983/84	ROE-SN	21.73	37.22	13.58	9.16	10.04	5.91	1.07	1.07	0.23	3079	1182	492.36
	ROE-GN	0.00	1.68	6.72	17.98	32.61	31.93	5.38	3.36	0.34	595	464	55.40
1984/85	ROE-SN	20.47	53.62	14.22	3.71	2.74	3.17	1.70	0.13	0.23	2995	644	16.34*
1985/86	ROE-SN	3.78	50.45	29.70	8.29	3.13	2.24	1.76	0.58	0.07	4151	602	16.77*
1986/87	ROE-SN	14.83	16.59	34.39	21.45	7.35	2.55	1.38	1.08	0.38	4708	1971	1007.50
	ROE-GN	0.00	1.82	24.55	61.82	5.45	2.18	2.91	0.91	0.36	550	408	144.31
1987/88	ROE-SN	2.56	60.97	7.66	14.75	9.87	2.80	0.74	0.44	0.21	7459	4721	667.13
	ROE-GN	0.00	5.40	7.00	40.80	29.40	12.80	3.00	1.20	0.40	500	607	86.67
1988/89	ROE-SN	2.56	15.81	60.96	6.58	8.67	4.53	0.68	0.18	0.04	5712	2510	756.40
	ROE-GN	0.00	0.26	54.45	10.99	22.25	9.42	1.57	1.05	0.00	382	145	232.76
1989/90	ROE-SN	0.48	27.17	12.43	47.33	4.49	5.94	1.83	0.23	0.09	6831	6315	563.72
	ROE-GN	0.00	1.35	7.87	68.99	8.31	10.34	2.47	0.67	0.00	445	428	125.93
1990/91	ROE-SN	6.59	21.41	21.11	10.67	33.10	3.01	3.43	0.66	0.03	7311	4577	497.89
	ROE-GN	0.00	0.29	7.16	11.75	63.90	8.02	8.02	0.57	0.29	349	223	147.29
1991/92	ROE-SN	1.62	47.83	10.54	13.43	6.02	17.01	2.11	1.22	0.22	5979	3775	259.62
	ROE-GN	0.00	6.29	13.49	30.76	13.85	29.86	2.88	2.52	0.36	556	617	40.66
1992/93	ROE-SN	3.94	27.77	40.59	6.65	7.51	4.11	7.72	0.94	0.57	5430	2772	473.30
1993/94	ROE-SN	2.98	22.32	23.76	30.53	8.05	5.10	5.41	1.59	0.25	6098	3120	447.32*
	ROE-GN	0.00	4.78	31.96	56.01	5.44	1.15	0.49	0.16	0.00	607	581	53.41
1994/95	ROE-SN	0.83	13.35	24.05	20.45	25.99	6.85	4.55	3.21	0.72	4832	1060	182.15*
1995/96	ROE-SN	14.20	21.22	13.04	18.79	13.11	14.17	3.15	1.37	0.95	6126	3332	123.92*
1996/97	ROE-SN	2.49	68.99	8.13	4.51	6.60	4.98	3.39	0.56	0.35	5698	3736	705.43
1997/98	ROE-SN	2.33	21.78	60.30	6.46	2.86	3.10	1.76	1.13	0.30	5065	2119	571.46
	ROE-GN	0.00	0.56	38.26	11.01	9.68	20.13	12.35	5.67	2.34	899	424	111.91
1998/99	WINTER	11.79	28.03	41.71	14.62	3.10	0.61	0.13	0.00	0.00	1484	117	161.58
	ROE-SN	6.18	24.63	41.42	18.55	6.53	1.78	0.70	0.15	0.05	3979	1113	518.40
	ROE-GN	0.00	2.15	29.31	36.72	21.05	6.70	3.35	0.60	0.12	836	338	522.51

	AVERAGE WEIGHT AT AGE (gms)								
FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	56.0	90.1	112.4	131.0	148.2	155.4	173.2	176.0	183.6
ROE-SN	64.0	93.2	121.1	144.7	163.6	177.5	187.4	195.8	198.9
ROE-GN	45.5	116.7	135.8	150.1	160.5	170.6	175.8	179.4	176.8

* - Age composition from published reports.
\- - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
- includes catch from "other" fisheries
^ - includes catch from seine roe fisheries
` - includes catch from gillnet fisheries

Appendix Table I.6. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all ~~seasons~~ for Area 27. These data are used for age-structured model analysis.

		PERCENT AT AGE									NUMBER	SAMPLE	CATCH
SEASON	FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+	AGED	WEIGHT	(x 10)
1953/54	WINTER	0.00	47.57	40.45	10.11	0.75	1.12	0.00	0.00	0.00	267	4376	206.40
1954/55	WINTER	6.80	34.77	49.72	6.94	1.42	0.28	0.07	0.00	0.00	1412	510	614.00
1963/64	WINTER	0.00	46.32	30.53	22.11	1.05	0.00	0.00	0.00	0.00	95	440	29.70
1964/65	WINTER	1.41	18.31	36.62	33.10	7.04	0.70	1.41	1.41	0.00	142	131	55.25
1975/76	ROE-GN	0.00	3.74	41.18	27.27	17.65	6.42	3.74	0.00	0.00	187	18	5.55
1977/78	WINTER	1.41	53.52	5.63	19.72	16.90	2.82	0.00	0.00	0.00	71	71	14.38`
1978/79	ROE-SN	1.25	12.50	68.75	12.50	2.50	1.25	1.25	0.00	0.00	80	80	40.35
	ROE-GN	0.00	1.06	48.94	17.02	20.21	11.70	1.06	0.00	0.00	94	3599	18.68
1979/80	ROE-GN	0.00	4.00	9.33	70.67	12.00	2.67	1.33	0.00	0.00	75	39	36.66
1980/81	ROE-SN	2.23	13.50	61.21	8.26	13.24	1.57	0.00	0.00	0.00	763	412	59.41`
1981/82	ROE-SN	0.66	35.00	9.93	41.53	4.07	7.95	0.76	0.09	0.00	1057	656	20.77
	ROE-GN	0.00	0.92	6.42	55.05	9.17	25.69	2.75	0.00	0.00	109	187	22.70
1982/83	ROE-SN	3.96	20.79	31.68	10.89	28.71	0.00	3.96	0.00	0.00	101	2997	1.00~
	ROE-GN	0.00	0.00	8.75	15.00	62.50	2.50	11.25	0.00	0.00	80	80	11.73
1983/84	ROE-GN	0.00	0.00	4.17	42.13	16.67	33.33	2.55	1.16	0.00	432	206	11.07
1985/86	ROE-SN	2.21	23.62	63.47	2.58	1.48	1.85	2.58	2.21	0.00	271	101	1.00~
1986/87	ROE-SN	17.02	27.66	15.96	35.46	1.06	0.00	1.06	0.35	1.42	282	216	1.00~
1987/88	ROE-SN	2.16	62.53	11.05	6.20	15.36	1.62	0.81	0.00	0.27	371	406	1.00~
1988/89	ROE-SN	0.21	12.66	57.51	8.15	8.37	11.37	1.29	0.43	0.00	466	139	1.00~
1989/90	ROE-SN	1.84	22.68	14.25	39.63	5.83	7.13	7.78	0.65	0.22	926	785	1.00~
1990/91	ROE-SN	8.97	39.40	8.97	10.33	22.55	2.72	4.89	2.17	0.00	368	257	19.05*
1991/92	ROE-SN	3.48	71.21	11.21	3.40	2.91	5.04	0.99	1.28	0.50	1410	668	46.16
1992/93	ROE-SN	10.50	33.33	40.88	5.52	1.29	1.66	5.71	0.37	0.74	543	310	30.55
	ROE-GN	0.00	3.28	53.28	14.09	7.92	7.53	11.58	0.97	1.35	518	283	25.02
1993/94	ROE-SN	1.48	31.75	24.55	30.90	5.50	2.12	2.86	0.53	0.32	945	677	30.39
	ROE-GN	0.00	1.28	19.40	61.19	9.81	3.41	3.84	0.43	0.64	469	325	24.55
1994/95	ROE-SN	1.68	6.37	35.29	24.37	24.65	4.13	1.33	1.61	0.56	1428	421	41.24*
1995/96	ROE-SN	14.18	22.70	6.38	20.57	15.60	16.67	2.84	0.35	0.71	282	403	30.09*
1996/97	ROE-SN	4.01	76.83	7.32	1.57	4.01	4.70	1.57	0.00	0.00	574	142	30.38
1997/98	ROE-SN	1.39	38.89	48.61	4.86	0.35	2.78	2.43	0.69	0.00	288	393	30.08
1998/99	ROE-SN	7.07	32.51	26.86	27.92	4.24	0.71	0.35	0.35	0.00	283	369	28.81

	AVERAGE WEIGHT AT AGE (gms)								
FISHERY	1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	69.2	91.1	119.9	146.3	164.8	174.1	202.7	208.8	0.0
ROE-SN	56.7	94.1	119.2	138.9	157.7	172.9	181.9	200.4	215.7
ROE-GN	0.0	114.9	134.4	144.1	152.1	155.8	166.3	179.0	196.2

* - Age composition from published reports.
~ - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
" - includes catch from "other" fisheries
^ - includes catch from seine roe fisheries
` - includes catch from gillnet fisheries

Appendix Table 1.7. Age-composition and catch in numbers by fishery and season and weight-at-age averaged over all seasons for Area 2W. These data are used for age-structured model analysis.

SEASON	FISHERY	PERCENT AT AGE 1+	2+	3+	4+	5+	6+	7+	8+	9+	NUMBER AGED	SAMPLE WEIGHT	CATCH (x 10)
1956/57	WINTER	0.00	63.41	31.71	2.44	2.44	0.00	0.00	0.00	0.00	41	41	12.10
1964/65	WINTER	0.00	46.00	8.00	28.00	8.00	6.00	4.00	0.00	0.00	50	50	85.99
1972/73	ROE-SN	0.00	7.80	19.86	18.44	46.81	4.96	1.42	0.71	0.00	141	655	43.98
1973/74	ROE-SN	7.62	25.71	23.33	21.90	8.10	11.43	1.90	0.00	0.00	210	110	32.07
1974/75	ROE-SN	0.53	45.72	32.89	12.57	3.48	3.74	1.07	0.00	0.00	374	161	30.56
1975/76	ROE-SN	23.71	6.70	41.24	23.71	4.64	0.00	0.00	0.00	0.00	194	593	1.00-
1977/78	ROE-SN	0.00	7.28	25.73	10.19	41.75	6.31	5.83	2.91	0.00	206	124	34.05
1978/79	ROE-SN	1.49	18.84	22.95	16.23	22.95	13.81	1.87	1.12	0.75	536	91	45.46*
1979/80	ROE-SN	0.00	70.00	15.29	6.47	4.71	2.94	0.00	0.59	0.00	170	45	1.00-
1980/81	ROE-SN	4.35	3.78	66.50	11.66	7.06	4.60	1.64	0.41	0.00	1218	100	57.30
1981/82	ROE-SN	1.80	37.54	1.45	51.39	4.11	2.14	1.16	0.35	0.06	1726	939	87.26
1982/83	ROE-SN	0.69	1.34	56.41	3.01	33.10	2.92	1.25	0.74	0.54	3356	140	161.04
1983/84	ROE-SN	6.45	1.61	0.60	35.28	2.42	51.01	1.81	0.60	0.20	496	427	1.00-
1984/85	ROE-SN	0.50	2.90	5.21	2.80	21.82	2.86	63.16	0.70	0.10	999	381	9.62
1985/86	ROE-SN	0.82	0.27	11.48	11.75	5.46	20.77	7.38	41.53	0.55	366	38	1.00-
1986/87	ROE-SN	22.14	61.32	0.25	1.27	1.27	1.27	8.14	1.02	3.31	393	398	1.00-
1987/88	ROE-SN	1.79	74.01	19.31	0.26	0.53	0.66	0.79	1.65	0.99	1512	166	1.00-
1988/89	ROE-SN	0.49	3.42	76.06	15.88	0.49	0.49	0.98	0.81	1.38	1228	330	1.00-
1989/90	ROE-SN	0.20	1.47	1.72	77.69	16.84	0.45	0.20	0.57	0.86	2447	2792	135.97
1990/91	ROE-SN	0.52	12.62	1.64	2.43	65.78	15.24	0.79	0.46	0.52	3288	2178	153.62
1991/92	ROE-SN	1.53	9.10	13.25	1.53	2.72	58.38	12.01	0.54	0.94	2023	804	71.79
1992/93	ROE-SN	1.01	13.77	16.84	14.48	2.06	4.69	41.15	5.25	0.75	2666	681	81.95
1993/94	ROE-SN	5.32	12.23	43.62	14.89	9.57	2.13	5.85	5.32	1.06	188	104	1.00-
1997/98	ROE-SN	18.50	34.75	23.10	18.68	2.62	0.63	1.53	0.18	0.00	1108	449	14.90
1998/99	ROE-SN	15.60	32.38	28.09	14.30	7.28	1.56	0.52	0.26	0.00	769	201	1.00-

FISHERY	AVERAGE WEIGHT AT AGE (gms) 1+	2+	3+	4+	5+	6+	7+	8+	9+
WINTER	50.0	89.2	122.1	125.7	166.0	196.0	216.5	0.0	0.0
ROE-SN	67.7	105.4	135.3	162.0	184.1	191.5	208.2	208.9	214.7
ROE-GN	53.2	81.9	139.8	162.0	187.7	191.9	199.0	0.0	0.0

* - Age composition from published reports.
- - No seine roe fishery in this season. Age composition from pre-fishery charter samples only.
* - includes catch from "other" fisheries
^ - includes catch from seine roe fisheries
` - includes catch from gillnet fisheries

Appendix table 2.1. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Queen Charlotte Islands stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	3503	1950	1023	208	136	57	0	0	0	4556	2510	0.17
1951/52	4887	2207	1191	515	94	58	24	0	0	5073	2398	0.02
1952/53	21656	2934	1206	469	152	23	14	6	0	10281	4759	0.00
1953/54	2698	13643	1848	760	295	96	15	9	4	15099	9853	0.34
1954/55	3458	1693	8530	1108	446	172	56	9	7	45350	6143	-1.23
1955/56	1095	2176	1063	5347	693	279	107	35	10	6125	4014	0.35
1956/57	1769	683	628	298	719	46	18	7	3	1718	1578	0.68
1957/58	4242	803	67	175	39	45	3	1	1	2656	787	-0.45
1958/59	1587	1370	247	22	34	5	6	0	0	8598	6941	0.56
1959/60	3799	718	619	128	10	15	2	3	0	13950	6470	0.00
1960/61	4647	2393	452	390	81	6	10	2	2	8854	6976	0.53
1961/62	8863	2925	1485	277	236	49	4	6	2	10814	4654	-0.07
1962/63	1826	5568	1649	727	119	95	20	2	3	14720	6176	-0.10
1963/64	4861	1147	2998	757	282	42	34	7	2	5097	4223	0.58
1964/65	382	3044	424	947	140	35	5	4	1	2203	1446	0.35
1965/66	294	203	137	113	110	6	2	0	0	2914	2764	0.72
1966/67	301	154	75	64	46	41	2	1	0	2907	710	-0.64
1967/68	639	189	91	45	38	27	24	1	0	3338	750	-0.72
1968/69	1839	401	117	56	28	23	16	15	1	4050	1877	0.00
1969/70	4263	1158	253	74	36	18	15	10	10	9296	4308	0.00
1970/71	3708	2685	730	159	46	22	11	9	13	29373	13616	0.00
1971/72	10399	2336	1692	460	100	29	14	7	14	18753	9951	0.14
1972/73	8308	6543	1381	954	246	52	15	7	11	23020	7706	-0.33
1973/74	7394	5233	3913	739	473	118	25	7	9	36326	9903	-0.53
1974/75	1942	4658	3155	2245	405	253	63	13	9	44418	8951	-0.83
1975/76	2520	1220	2791	1808	1231	217	136	34	12	35843	15143	-0.09
1976/77	2849	1584	747	1482	864	550	97	60	20	28678	12516	-0.06
1977/78	1608	1794	844	384	689	382	243	43	36	17522	11452	0.34
1978/79	31732	1012	970	417	158	253	136	87	28	9625	8657	0.66
1979/80	2299	19969	620	466	154	51	79	42	36	36749	21204	0.22
1980/81	939	1447	12396	376	252	76	24	38	38	59302	19024	-0.37
1981/82	1014	591	900	7446	213	132	39	12	38	60203	19009	-0.38
1982/83	6891	638	364	551	4461	125	74	22	29	50017	19082	-0.19
1983/84	3051	4326	385	217	318	2529	70	42	28	40359	20438	0.09
1984/85	708	1914	2613	229	124	180	1422	39	40	34009	14393	-0.09
1985/86	1445	442	1160	1516	126	66	94	743	41	30125	5636	-0.91
1986/87	10232	910	274	688	868	71	37	52	438	23579	13133	0.18
1987/88	3949	6444	560	164	403	503	41	21	284	29985	14456	0.04
1988/89	1372	2487	4058	352	103	254	317	26	192	36052	23986	0.36
1989/90	875	862	1546	2493	214	62	153	191	132	30610	25011	0.57
1990/91	4300	550	503	880	1326	109	31	76	160	20415	14220	0.41
1991/92	347	2684	331	279	456	658	53	15	114	20522	9500	0.00
1992/93	224	216	1588	189	153	245	353	28	69	13392	5405	-0.14
1993/94	917	140	126	854	95	74	118	170	47	10685	4895	-0.01
1994/95	3636	571	84	74	484	53	41	66	121	10729	4946	-0.01
1995/96	6268	2291	360	53	46	304	33	26	118	14444	5827	-0.14
1996/97	17100	3949	1443	226	33	29	192	21	90	17669	11686	0.36
1997/98	563	10767	2480	900	141	21	18	119	69	30336	18871	0.29
1998/99	1855	354	6657	1500	535	83	12	11	111	40372	9714	-0.66

Estimated average availability at age (S_i)

0.12 0.43 0.62 0.88 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.01 0.03 0.19 0.52 0.77 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.46

Estimated instantaneous natural mortality rate is 0.462

Appendix table 2.2. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Prince Rupert stock assessment region.

	Estimated numbers at age (x 10^5) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	7345	7721	9204	1237	447	237	0	0	0	15607	30098	1.20
1951/52	7463	4215	3950	3466	338	87	46	0	0	7481	18726	1.46
1952/53	17807	4289	2231	1284	684	34	9	5	0	30031	26180	0.40
1953/54	5467	10586	2500	1294	736	388	19	5	3	11291	13291	0.70
1954/55	13990	3210	5747	951	361	149	78	4	2	17286	25629	0.93
1955/56	4501	8283	1846	2589	363	119	49	26	2	46636	15498	-0.56
1956/57	8529	2585	4401	1011	1360	185	61	25	14	20079	28280	0.88
1957/58	16229	4830	1158	1879	351	390	53	17	11	40897	12044	-0.68
1958/59	5105	9442	2742	657	1040	191	212	29	16	44841	36608	0.34
1959/60	27037	3011	5167	1498	344	526	96	107	22	36624	19072	-0.11
1960/61	13553	15186	1677	2602	689	147	225	41	55	34379	12883	-0.44
1961/62	7412	7712	6965	732	941	210	45	69	29	36031	24760	0.16
1962/63	21057	4351	4028	3322	309	356	80	17	37	29279	15652	-0.09
1963/64	2785	11143	2122	1734	1171	91	105	23	16	42379	29266	0.17
1964/65	673	1559	4925	1024	745	456	35	41	15	12529	6709	-0.08
1965/66	1060	244	574	1790	260	127	78	6	10	7913	7487	0.48
1966/67	1686	630	102	236	582	67	33	20	4	4540	2719	0.03
1967/68	1783	657	179	39	67	121	14	7	5	6076	4788	0.30
1968/69	7765	983	306	94	19	31	57	7	6	3612	844	-0.91
1969/70	5076	4606	571	170	50	10	16	29	6	14600	8436	-0.01
1970/71	1840	2992	2651	326	95	28	6	9	20	18447	9751	-0.10
1971/72	11485	1074	1627	1470	174	49	14	3	15	18381	9852	-0.08
1972/73	10467	6829	624	868	742	84	24	7	9	22746	11260	-0.16
1973/74	3915	6223	4025	358	490	413	47	13	9	29509	8893	-0.66
1974/75	1397	2328	3671	2270	189	249	210	24	11	35982	11109	-0.64
1975/76	3121	829	1372	2132	1304	108	142	120	20	36826	14213	-0.41
1976/77	1590	1856	491	772	1164	696	57	76	74	25271	9736	-0.41
1977/78	1696	945	1035	256	369	521	310	26	67	13468	4738	-0.51
1978/79	29069	1004	519	502	103	128	179	107	32	9756	7554	0.28
1979/80	5259	17278	560	262	224	41	51	71	55	20640	10236	-0.16
1980/81	6555	3125	10085	308	128	101	18	23	56	37826	10532	-0.74
1981/82	6792	3896	1829	5771	170	67	53	10	42	44175	12631	-0.71
1982/83	19840	4033	2282	1063	3316	97	38	30	29	49827	19653	-0.39
1983/84	3732	11796	2398	1356	632	1971	58	23	35	45781	22927	-0.15
1984/85	3504	2218	6951	1396	769	345	1043	30	31	44903	35858	0.31
1985/86	13175	2082	1295	3963	758	388	162	491	29	45394	32526	0.21
1986/87	10799	7828	1195	723	2055	370	185	77	248	41863	31422	0.25
1987/88	6390	6419	4580	684	386	1018	177	88	155	37095	33680	0.44
1988/89	3325	3798	3709	2583	358	175	429	74	103	35218	12783	-0.47
1989/90	14241	1975	2182	2080	1328	152	67	164	68	36293	19398	-0.09
1990/91	14505	8466	1138	1245	1135	679	75	33	114	39166	21544	-0.06
1991/92	3768	8622	4932	652	681	592	338	37	73	42610	35992	0.37
1992/93	1776	2240	5034	2842	343	318	257	147	48	36017	21440	0.02
1993/94	4938	1055	1301	2840	1497	151	121	98	74	28377	13439	-0.21
1994/95	20406	2934	614	730	1513	741	65	52	74	24475	15858	0.11
1995/96	9329	12128	1724	353	405	807	377	33	64	39562	22104	-0.04
1996/97	15161	5545	7131	1003	196	192	359	168	43	31071	20744	0.14
1997/98	1834	9013	3276	4139	520	71	41	77	45	39482	16734	-0.32
1998/99	1055	1090	5317	1910	2311	263	15	9	26	43360	25699	0.02

Estimated average availability at age (S_i)

0.07 0.36 0.54 0.80 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.13 0.18 0.47 0.73 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.58

Estimated instantaneous natural mortality rate is 0.520

Appendix table 2.3. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Central Coast stock assessment region.

	Estimated numbers at age (x 10^{-5}) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	1694	3134	4070	751	302	78	0	0	0	14350	23134	0.56
1951/52	2277	1202	1436	1420	185	66	17	0	0	3839	10709	1.11
1952/53	13090	1598	420	365	182	17	6	2	0	10501	20001	0.73
1953/54	1555	9901	1191	304	261	130	12	4	1	8668	18635	0.85
1954/55	1681	1059	5378	405	71	54	27	3	1	27619	14983	-0.53
1955/56	3907	1206	727	3233	228	39	30	15	2	7108	8244	0.23
1956/57	5605	2359	430	199	494	27	5	4	2	3115	6224	0.78
1957/58	6551	3881	686	114	28	53	3	1	1	12121	4226	-0.97
1958/59	1604	4667	2186	353	52	12	23	1	0	5330	4105	-0.17
1959/60	3187	1110	2180	634	61	7	2	3	0	25779	14684	-0.48
1960/61	8815	2181	737	1497	424	41	5	1	2	7058	4567	-0.35
1961/62	4320	6215	739	226	291	69	7	1	1	14274	14181	0.08
1962/63	3854	3123	3825	359	95	116	28	3	1	4748	8467	0.66
1963/64	1877	2904	1293	971	46	9	11	3	0	4636	7058	0.51
1964/65	1948	1047	819	341	136	5	1	1	0	3365	2365	-0.27
1965/66	5466	1382	384	242	61	20	1	0	0	1926	1774	0.00
1966/67	1927	1206	154	84	20	3	1	0	0	3385	5905	0.64
1967/68	468	262	164	44	14	3	0	0	0	3671	6366	0.64
1968/69	1924	296	146	99	25	8	2	0	0	3749	2331	-0.39
1969/70	1642	1454	222	108	73	19	6	1	0	14133	10134	-0.25
1970/71	2077	1231	1092	166	81	55	14	4	1	15331	6056	-0.84
1971/72	3514	1532	828	717	105	50	34	9	3	10668	3928	-0.91
1972/73	2295	2627	957	407	302	42	20	14	5	20420	14471	-0.26
1973/74	3049	1731	1722	575	220	158	22	10	10	18547	10624	-0.47
1974/75	1473	2300	1259	1050	280	93	64	9	8	24899	9165	-0.91
1975/76	759	1111	1645	811	552	132	42	29	8	18978	16134	-0.08
1976/77	861	560	780	998	373	211	47	15	13	17820	18481	0.12
1977/78	596	649	356	473	475	149	81	18	11	6337	10097	0.55
1978/79	6018	451	389	171	117	56	14	7	3	7148	6550	0.00
1979/80	1155	4554	341	294	130	88	43	10	8	22553	15978	-0.26
1980/81	1236	874	3443	256	214	90	60	29	12	27828	16949	-0.41
1981/82	549	935	657	2518	172	129	48	32	22	30530	18412	-0.42
1982/83	461	413	675	458	1579	102	72	27	30	24348	16618	-0.30
1983/84	1790	348	300	470	292	946	59	42	33	15553	14197	0.00
1984/85	747	1343	242	192	268	150	463	29	37	16588	8480	-0.58
1985/86	1409	560	928	155	111	148	80	246	35	15736	15534	0.07
1986/87	8323	1060	396	619	97	68	89	48	169	15808	12992	-0.11
1987/88	589	6291	759	263	383	59	41	53	130	33272	27018	-0.12
1988/89	522	442	4528	526	172	241	37	25	114	31829	32335	0.10
1989/90	1666	388	307	2951	299	89	117	18	68	29369	31048	0.14
1990/91	8248	1257	270	204	1797	168	48	63	46	22408	20155	-0.02
1991/92	1014	6231	843	166	114	950	86	25	56	32270	46036	0.44
1992/93	1813	753	4289	544	100	66	540	49	46	31927	39713	0.30
1993/94	500	1350	517	2693	311	54	33	272	48	29334	29781	0.10
1994/95	1700	368	835	314	1475	161	26	16	156	18302	18919	0.12
1995/96	6277	1281	237	480	161	713	75	12	80	16457	17941	0.17
1996/97	6133	4704	891	149	283	92	406	43	53	24315	25208	0.12
1997/98	1153	4632	3306	600	97	178	57	251	59	29907	29386	0.07
1998/99	263	867	3134	2060	351	54	93	30	162	32960	28924	-0.04

Estimated average availability at age (S_i)

0.15 0.56 0.76 0.95 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.03 0.20 0.51 0.77 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 0.92

Estimated instantaneous natural mortality rate is 0.279

Appendix table 2.4. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the Strait of Georgia stock assessment region.

	Estimated numbers at age (x 10^5) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	18520	8607	3226	703	138	46	0	0	0	24969	66063	0.75
1951/52	21473	10175	3028	875	181	34	12	0	0	29325	66048	0.58
1952/53	37655	11563	3751	856	236	48	9	3	0	55311	100513	0.37
1953/54	23050	20879	6010	1891	429	118	24	5	2	37389	90437	0.66
1954/55	13486	12753	9480	1617	483	107	29	6	2	74870	74227	-0.24
1955/56	12570	7280	4640	3304	548	161	36	10	2	28310	29494	-0.19
1956/57	10446	6637	2264	1032	683	109	32	7	2	16555	28997	0.33
1957/58	27497	5755	1267	430	178	112	18	5	2	12100	20358	0.29
1958/59	19212	15156	2336	346	112	45	28	4	2	29493	44278	0.18
1959/60	10010	9949	5668	637	90	28	11	7	2	32226	37223	-0.08
1960/61	23658	5195	3044	1393	147	20	6	3	2	19726	25519	0.03
1961/62	21200	12011	1897	714	306	31	4	1	1	21924	23281	-0.17
1962/63	20378	11349	3238	394	137	56	6	1	0	12666	27751	0.56
1963/64	10032	10350	3425	488	52	17	7	1	0	11692	20366	0.33
1964/65	5115	5276	2613	448	54	5	2	1	0	20684	18628	-0.33
1965/66	4990	2364	1158	610	98	11	1	0	0	4077	5108	0.00
1966/67	2779	2229	558	131	56	8	1	0	0	4497	6345	0.12
1967/68	1804	658	225	74	15	6	1	0	0	6591	12022	0.37
1968/69	5617	952	303	105	34	7	3	0	0	14605	18208	-0.01
1969/70	6435	3083	511	163	56	18	4	1	0	27907	44194	0.23
1970/71	5064	3561	1677	279	89	31	10	2	1	25643	47312	0.39
1971/72	8106	2804	1938	894	148	47	16	5	2	23573	25875	-0.13
1972/73	12228	4438	1318	829	376	62	20	7	3	20933	18257	-0.36
1973/74	16522	6797	2337	575	340	151	25	8	4	51057	64619	0.01
1974/75	11417	9178	3724	1217	268	146	63	10	5	64312	76692	-0.05
1975/76	19594	6348	5033	1920	535	110	60	26	6	48736	57135	-0.07
1976/77	15526	10880	3465	2493	826	190	38	20	11	68957	58004	-0.40
1977/78	8386	8610	5621	1641	1048	323	72	14	12	57683	97082	0.29
1978/79	11592	4653	4361	2503	628	361	107	24	9	47844	59042	-0.02
1979/80	8843	6436	2441	1961	989	231	131	39	12	55832	74848	0.07
1980/81	7111	4915	3495	1297	973	461	107	60	23	51325	48231	-0.29
1981/82	5632	3929	2549	1734	576	397	183	42	33	42867	90239	0.52
1982/83	4964	3105	1975	1213	760	221	141	65	27	23401	47423	0.48
1983/84	8041	2740	1495	747	348	193	47	30	19	20234	27588	0.08
1984/85	12349	4432	1346	609	216	80	43	10	11	28501	26629	-0.30
1985/86	6987	6785	2302	618	227	69	24	13	6	51791	61097	-0.06
1986/87	21942	3882	3749	1271	341	125	38	13	11	41564	39037	-0.29
1987/88	6684	12174	2033	1821	520	115	36	11	7	59466	25351	-1.08
1988/89	16229	3711	6618	1010	801	210	43	13	7	58346	54078	-0.30
1989/90	7863	9003	2022	3411	450	325	80	16	8	81363	58912	-0.55
1990/91	20369	4373	4965	1073	1583	186	129	32	10	59871	43421	-0.55
1991/92	14655	11316	2383	2519	475	627	69	48	15	72896	80122	-0.13
1992/93	15058	8133	6022	1171	1069	181	232	26	24	86324	84961	-0.24
1993/94	7040	8304	4287	2965	506	419	67	86	18	65964	60862	-0.31
1994/95	12866	3889	4344	2042	1163	160	121	19	30	54993	59708	-0.14
1995/96	18073	7113	2058	2108	849	444	58	44	18	63365	76291	-0.04
1996/97	19002	9944	3558	991	886	316	159	21	22	58596	53442	-0.32
1997/98	7875	10491	4978	1648	395	292	96	48	13	56973	68699	-0.04
1998/99	7599	4351	5469	2392	666	125	61	20	13	52694	70165	0.06

Estimated average availability at age (S_i)

0.11 0.70 0.93 0.98 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

0.00 0.02 0.21 0.58 0.85 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.26

Estimated instantaneous natural mortality rate is 0.586

Appendix table 2.5. Estimates of numbers at age, spawn index (SI), estimated spawning stock biomass (SB), estimated spawn-observed spawn residuals (RES), and other parameters from age-structured analysis for the west coast Vancouver Island stock assessment region.

	Estimated numbers at age (x 10^5) for period 1											
Season	1+	2+	3+	4+	5+	6+	7+	8+	9+	SB	SI	RES
1950/51	3307	2250	2736	389	110	27	0	0	0	17664	17007	-0.21
1951/52	4426	1893	797	1047	134	36	9	0	0	1955	14383	1.83
1952/53	7162	2788	747	132	101	8	2	1	0	15688	30675	0.50
1953/54	4228	4561	1775	476	84	64	5	1	0	7200	16556	0.66
1954/55	5680	2615	1075	393	77	11	8	1	0	21647	17555	-0.38
1955/56	7336	3524	1353	579	206	40	6	4	0	23082	45168	0.50
1956/57	8694	4550	1431	604	242	83	16	2	2	35722	52651	0.22
1957/58	11357	5530	2733	869	364	146	50	10	3	45608	24399	-0.79
1958/59	7629	7226	3497	1727	548	230	92	32	8	10876	18396	0.36
1959/60	4191	4622	2082	715	245	60	25	10	4	5075	7039	0.16
1960/61	10107	2297	645	359	75	17	4	2	1	4865	7912	0.32
1961/62	4811	5473	566	139	55	9	2	1	0	14513	34579	0.70
1962/63	6489	2972	1858	196	42	16	3	1	0	7132	14618	0.55
1963/64	1711	4109	1294	539	47	9	3	1	0	12078	27863	0.67
1964/65	1529	1049	1641	433	156	13	2	1	0	10757	10864	0.16
1965/66	1955	952	330	579	135	45	4	1	0	4338	4584	-0.11
1966/67	769	1184	487	95	136	28	10	1	0	4426	5118	-0.02
1967/68	1345	373	210	125	19	24	5	2	0	9519	11278	0.00
1968/69	6363	857	237	133	80	12	15	3	1	9461	11206	0.00
1969/70	12847	4052	546	151	85	51	8	10	3	29484	34923	0.00
1970/71	9420	8182	2581	348	96	54	32	5	8	27458	32476	0.00
1971/72	11473	5999	5211	1644	221	61	34	21	8	61028	36069	-0.70
1972/73	12111	7291	3731	3049	949	127	35	20	16	72582	16219	-1.67
1973/74	20176	7705	4271	1995	1569	479	64	18	18	93828	24774	-1.50
1974/75	8516	12763	4439	2404	1053	801	244	33	18	111392	44594	-1.08
1975/76	5197	5415	7358	2411	1185	503	382	116	24	63447	63335	-0.17
1976/77	8394	3307	3307	3541	904	396	166	126	46	48705	57398	-0.01
1977/78	2416	5340	1949	1564	1424	321	138	58	60	41729	39931	-0.21
1978/79	5384	1533	3129	1049	616	434	88	38	32	27184	63663	0.68
1979/80	3793	3423	856	1526	377	179	121	25	20	33261	62619	0.46
1980/81	2029	2411	2113	517	863	197	92	62	23	32719	58518	0.41
1981/82	1374	1278	1381	1179	254	395	86	40	37	25608	29424	-0.03
1982/83	2682	869	762	796	621	119	175	38	34	17747	15329	-0.32
1983/84	5844	1688	445	374	341	246	46	67	28	18716	22142	0.00
1984/85	5449	3616	900	222	174	154	110	21	43	37821	29132	-0.43
1985/86	2156	3467	2295	571	141	110	97	70	40	47971	38347	-0.39
1986/87	13326	1373	2200	1456	362	89	70	62	70	32056	29915	-0.24
1987/88	2282	8341	708	1030	626	150	37	29	54	41999	39289	-0.24
1988/89	2871	1437	4906	382	526	313	75	18	41	41182	43331	-0.12
1989/90	1645	1810	795	2537	181	237	140	33	27	35324	38337	-0.09
1990/91	5501	1045	999	422	1271	88	115	68	29	23929	25907	-0.09
1991/92	2918	3471	559	512	199	567	39	51	43	25857	36811	0.18
1992/93	2248	1854	2086	319	282	108	307	21	50	26314	29237	-0.06
1993/94	1029	1413	1052	1133	169	148	57	160	37	20582	19765	-0.21
1994/95	1734	643	800	549	560	81	70	27	93	18270	25039	0.15
1995/96	8378	1103	385	459	310	314	45	39	67	16966	31929	0.46
1996/97	2834	5319	676	229	270	182	184	26	62	27364	39114	0.19
1997/98	1910	1787	2905	357	117	136	91	93	45	20512	36898	0.42
1998/99	602	1203	1016	1496	171	48	50	34	51	18964	18829	-0.18

Estimated average availability at age (S_i)

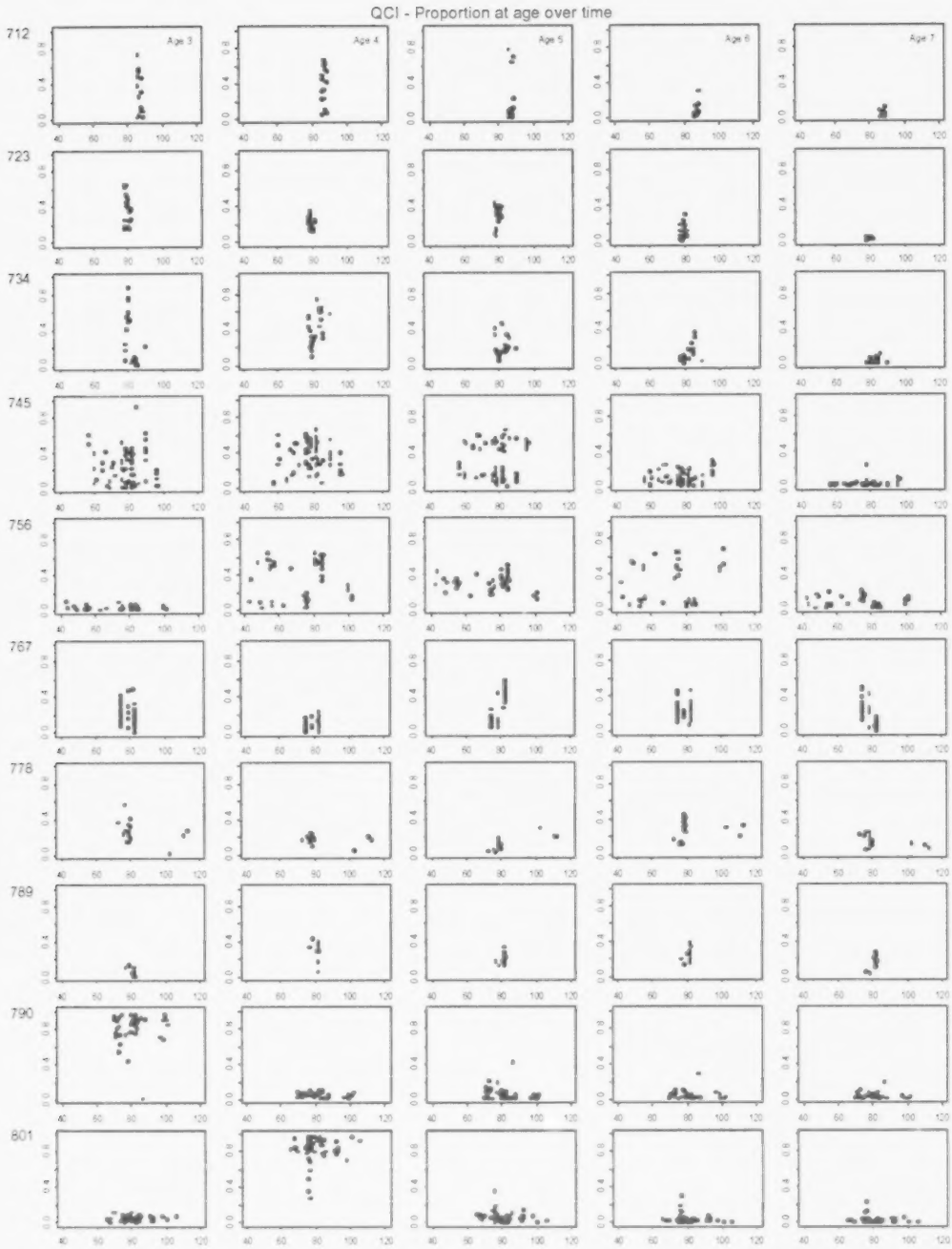
0.09 0.64 0.82 0.94 1.00 1.00 1.00 1.00 1.00

Estimated average relative selectivity at age for gillnet fisheries

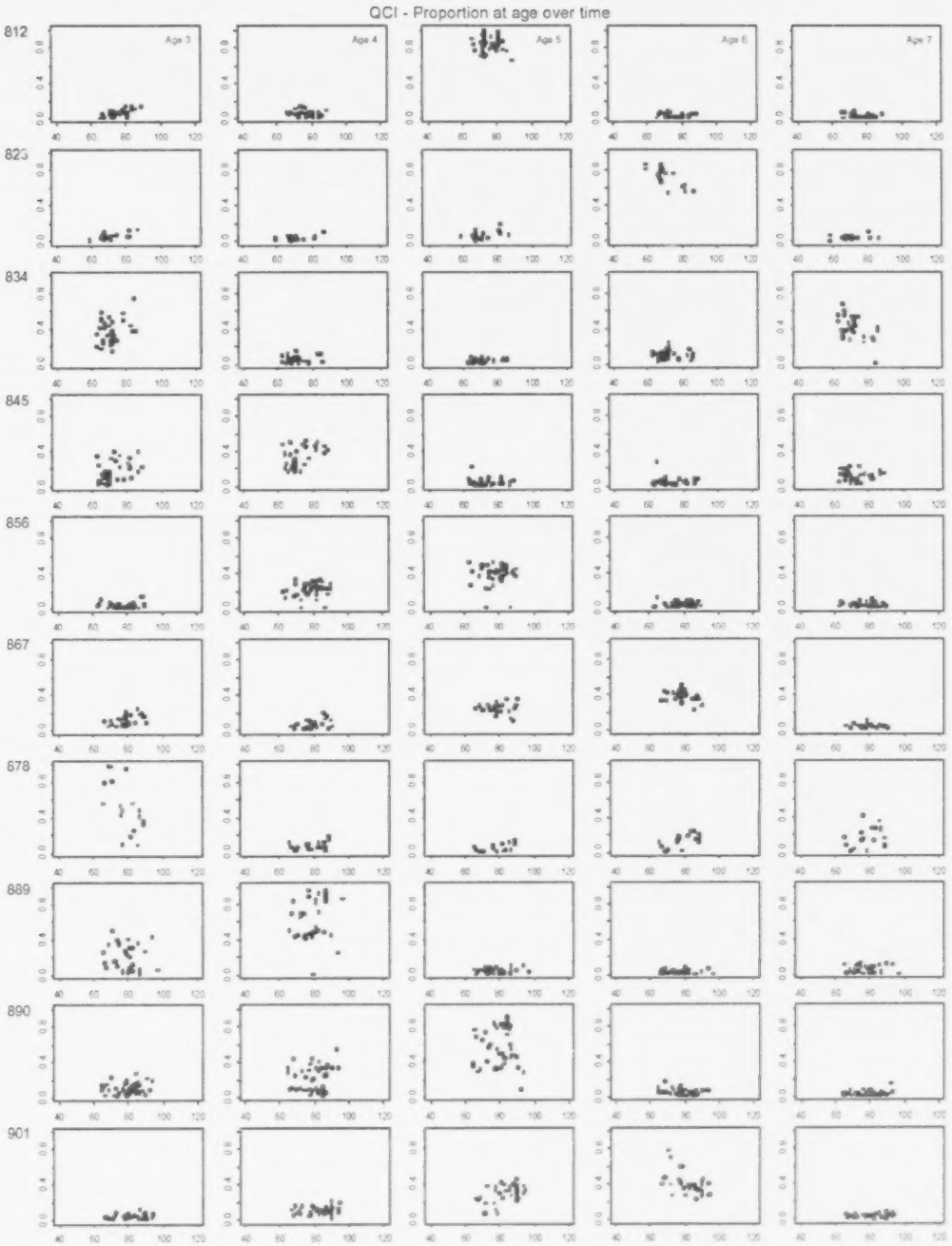
0.00 0.03 0.31 0.69 0.89 1.00 1.00 1.00 1.00

Spawn index-escapement conversion factor (q) is 1.18

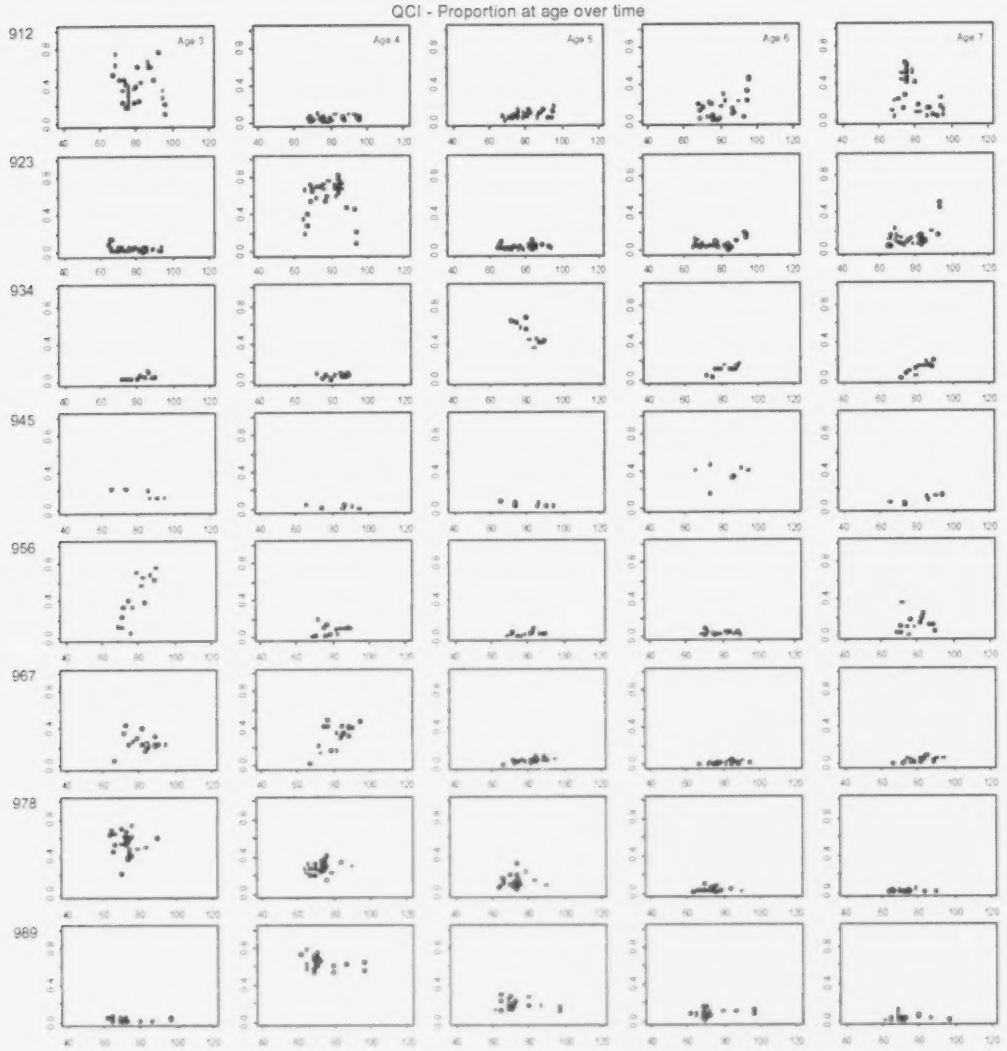
Estimated instantaneous natural mortality rate is 0.451



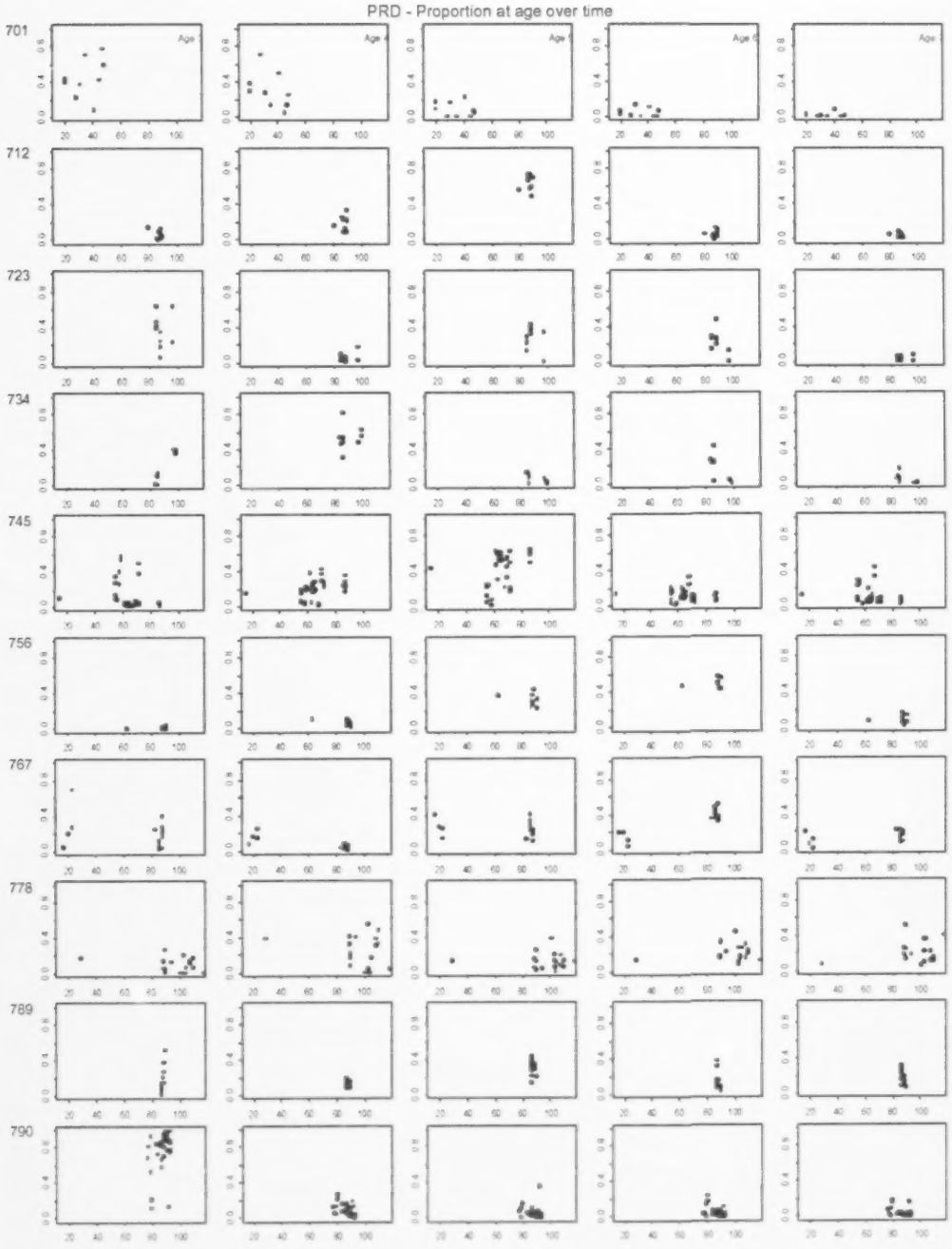
Appendix 3.1. Proportion of fish at ages 3 to 7 by sample and Julian day for the Queen Charlotte Islands from 1971-1999.



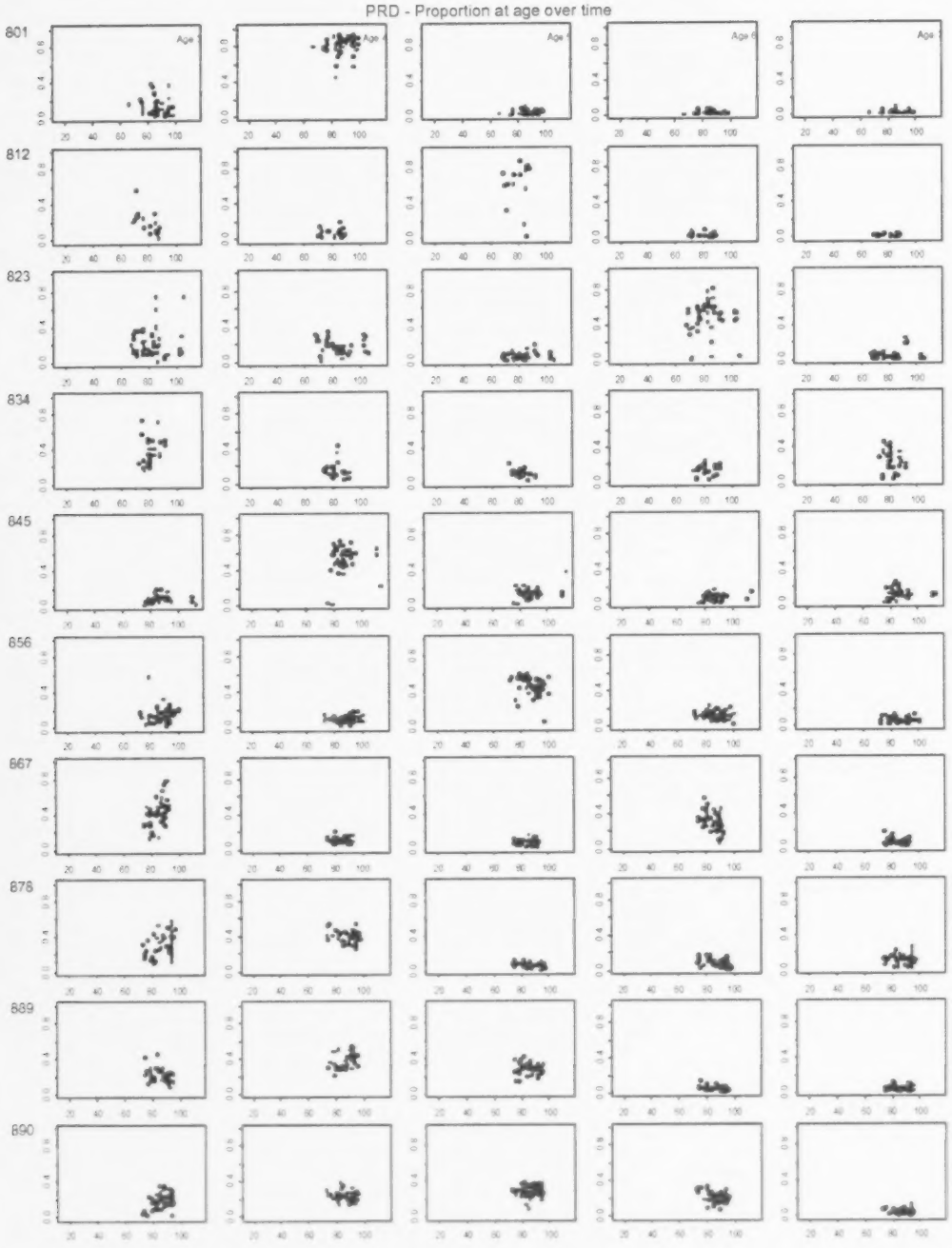
Appendix 3.1 (cont'd) Proportion of fish at ages 3 to 7 by sample and Julian day for the Queen Charlotte Islands from 1971-1999.



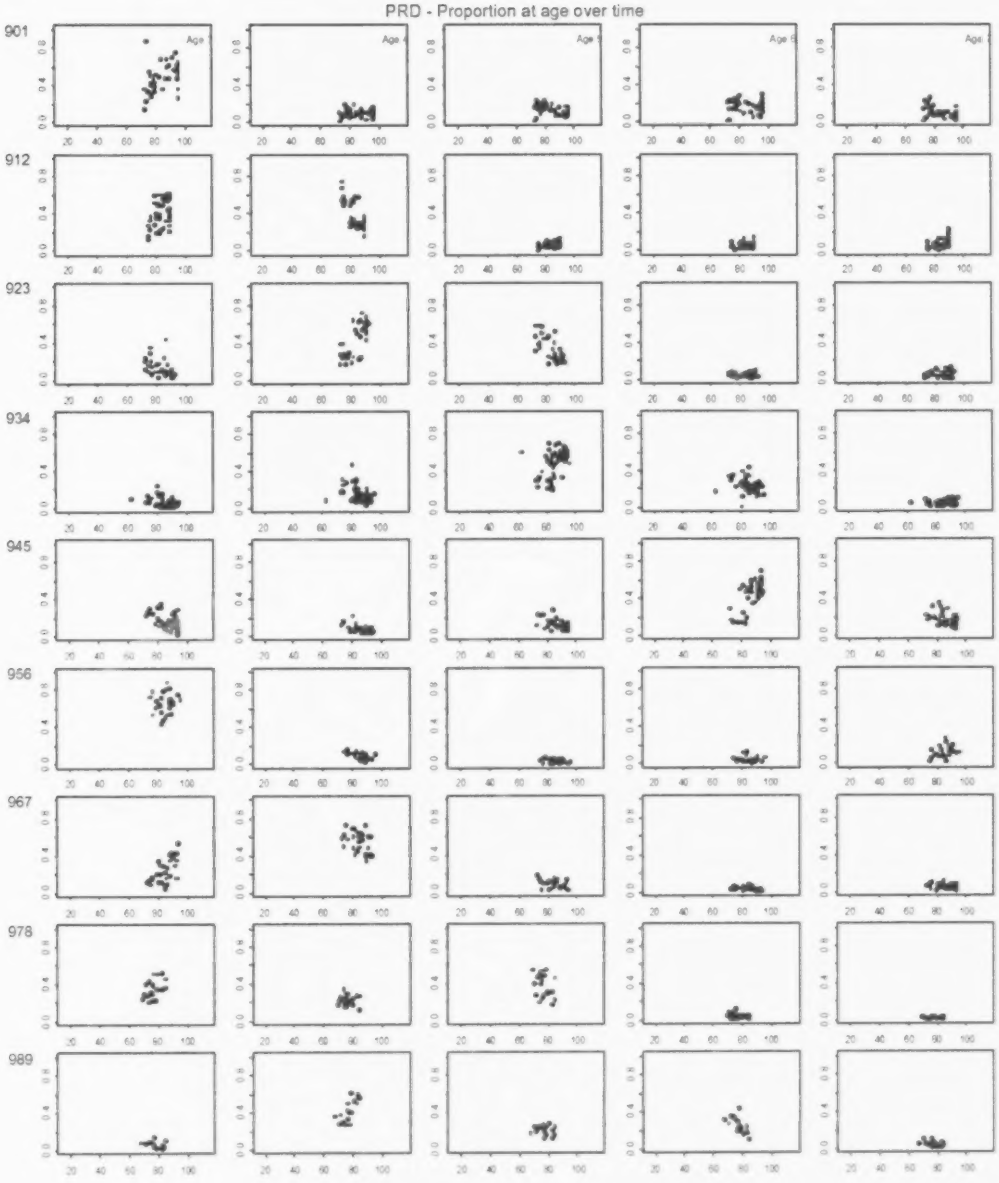
Appendix 3.1 (cont'd) Proportion of fish at ages 3 to 7 by sample and Julian day for the Queen Charlotte Islands from 1971-1999.



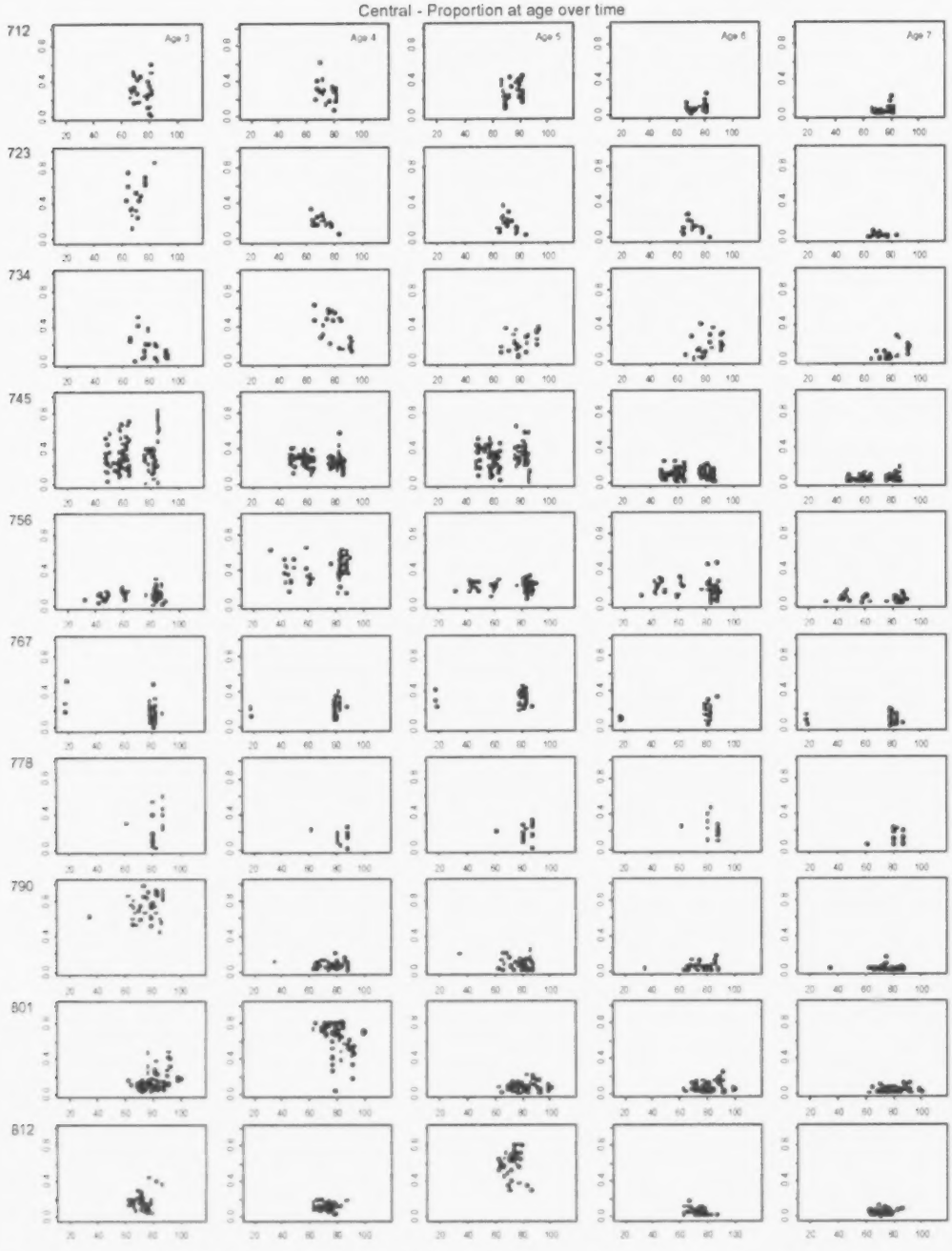
Appendix 3.2. Proportion of fish at ages 3 to 7 by sample and Julian day for the Prince Rupert District from 1971-1999.



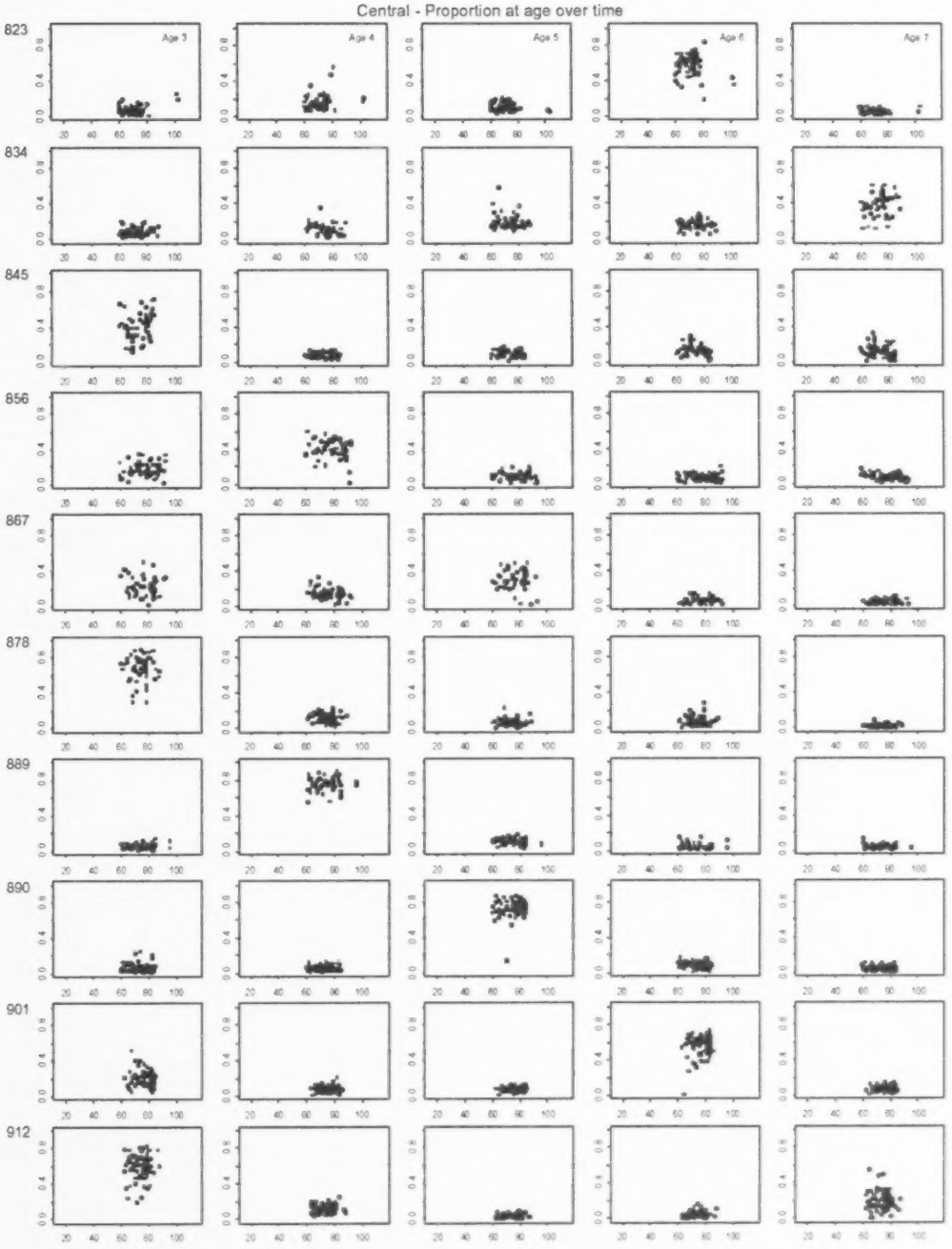
Appendix 3.2 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the Prince Rupert District from 1971-1999.



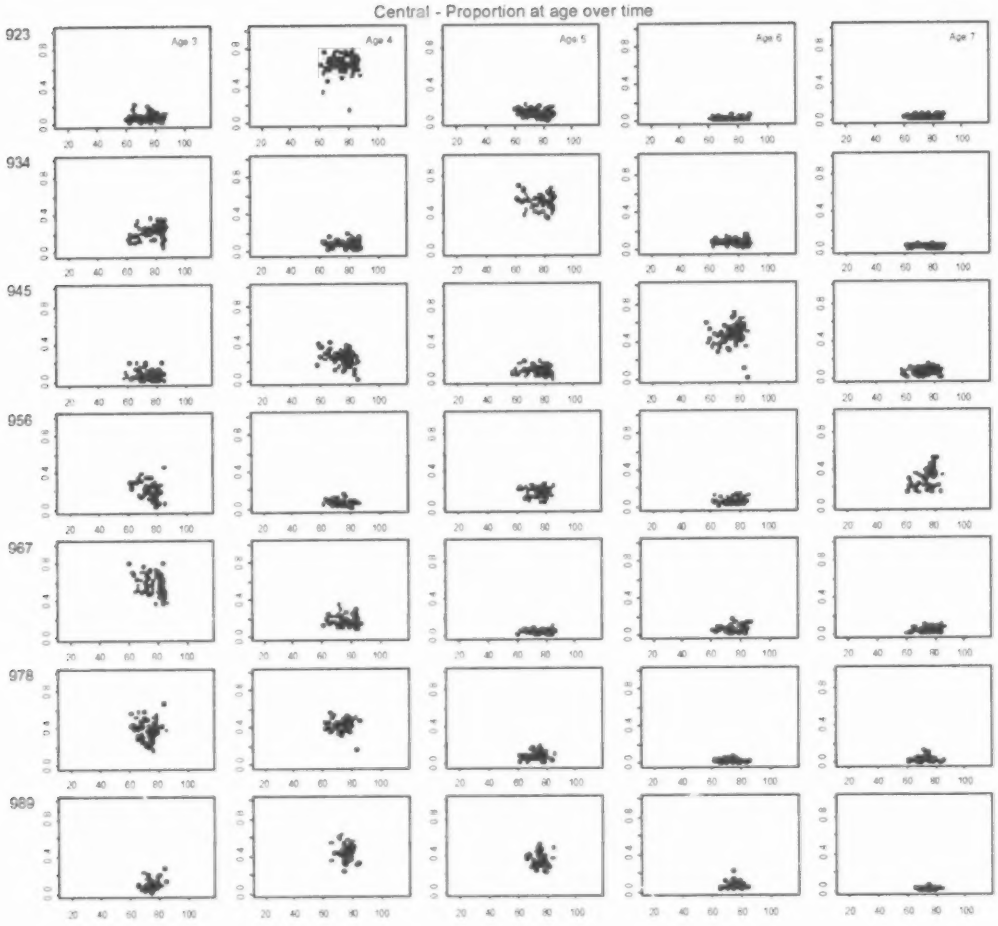
Appendix 3.2 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the Prince Rupert District from 1971-1999.



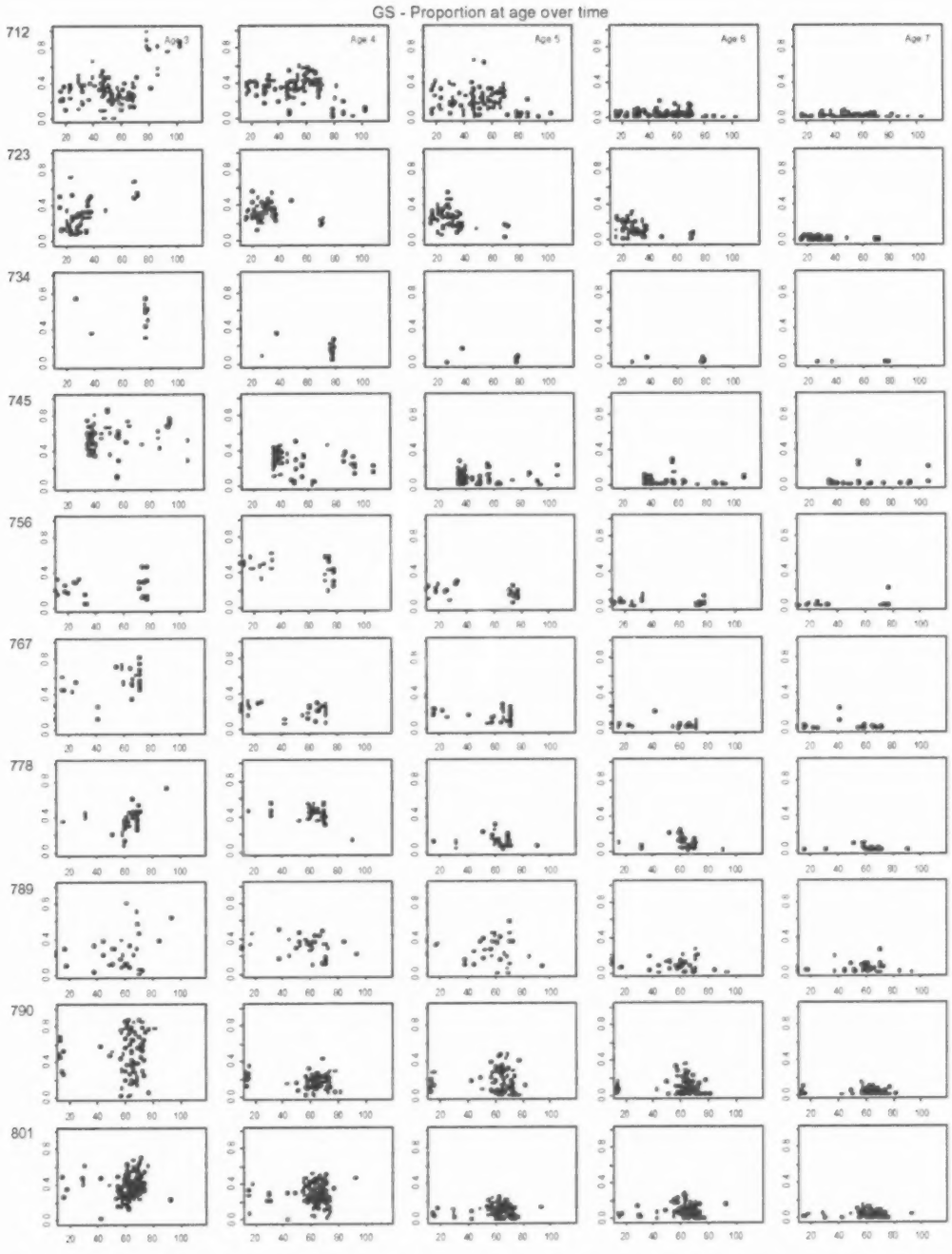
Appendix 3.3. Proportion of fish at ages 3 to 7 by sample and Julian day for the Central Coast from 1971-1999.



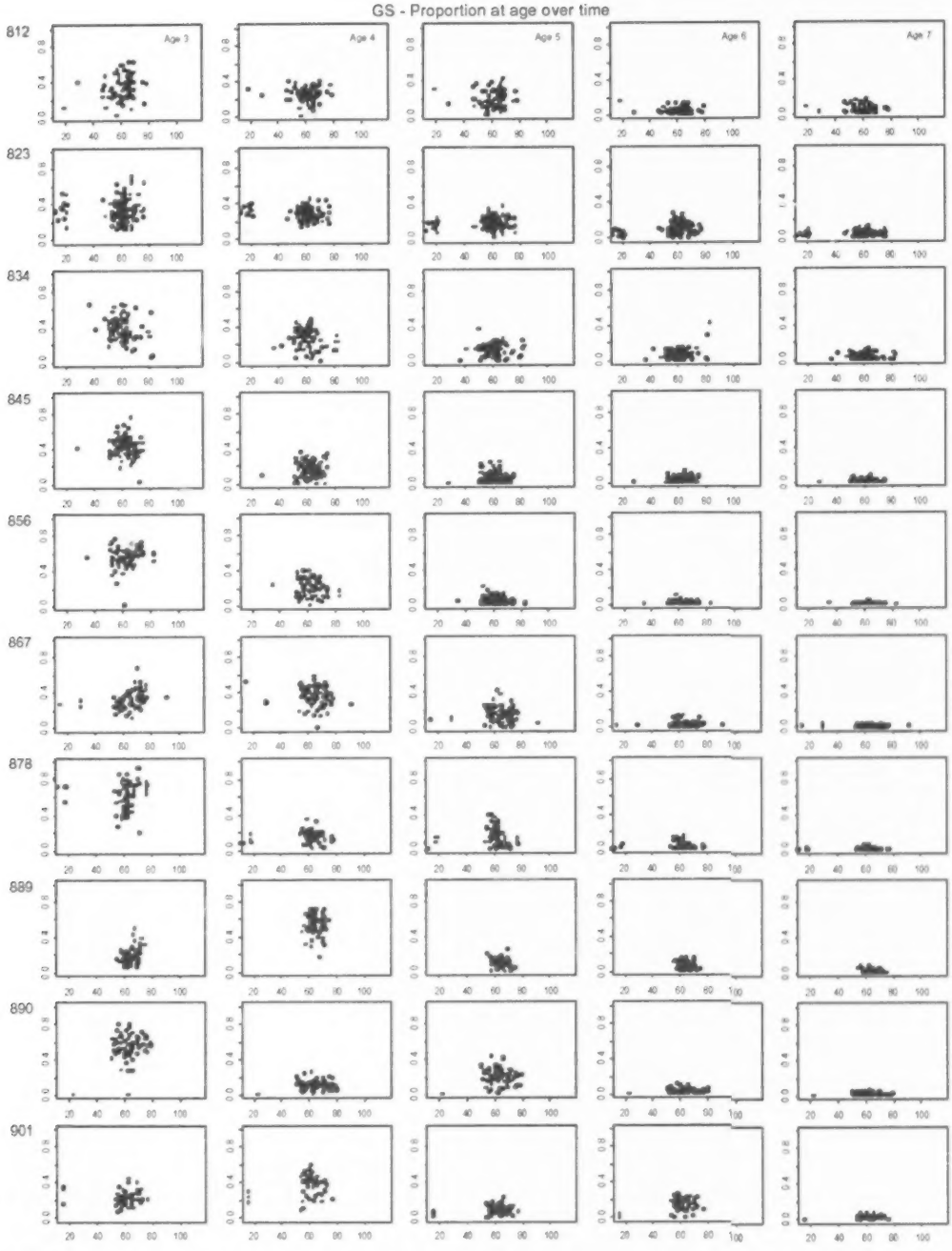
Appendix 3.3 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the Central Coast from 1971-1999.



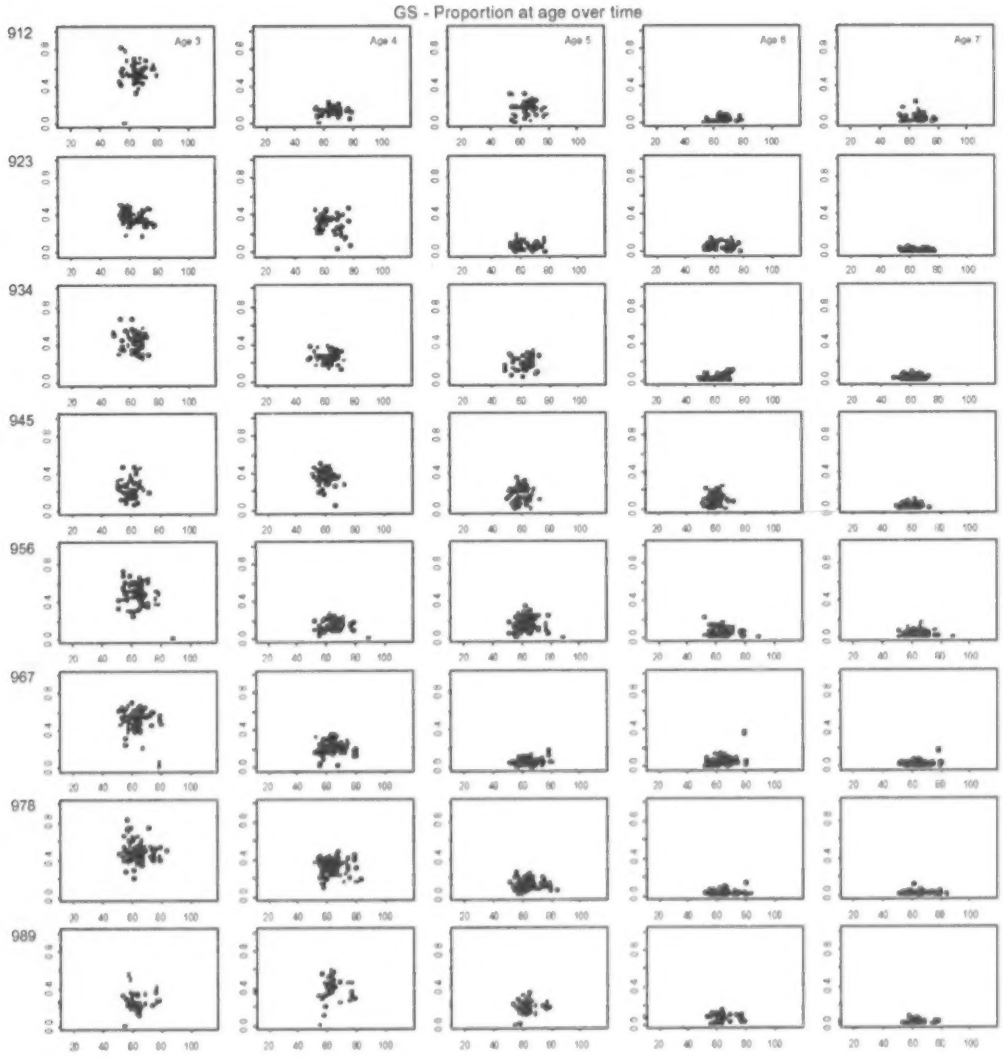
Appendix 3.3 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the Central Coast from 1971-1999.



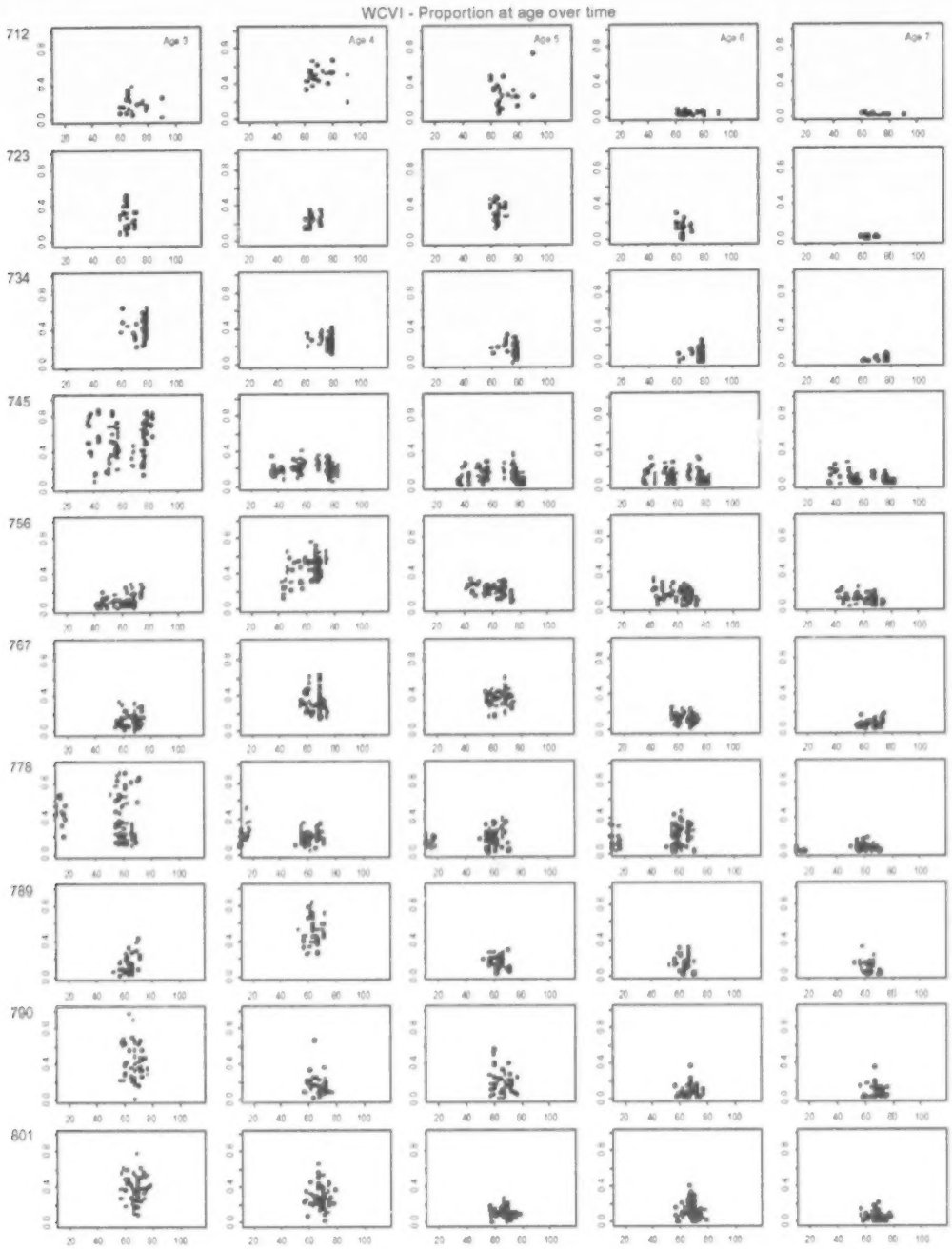
Appendix 3.4. Proportion of fish at ages 3 to 7 by sample and Julian day for the Strait of Georgia from 1971-1999.



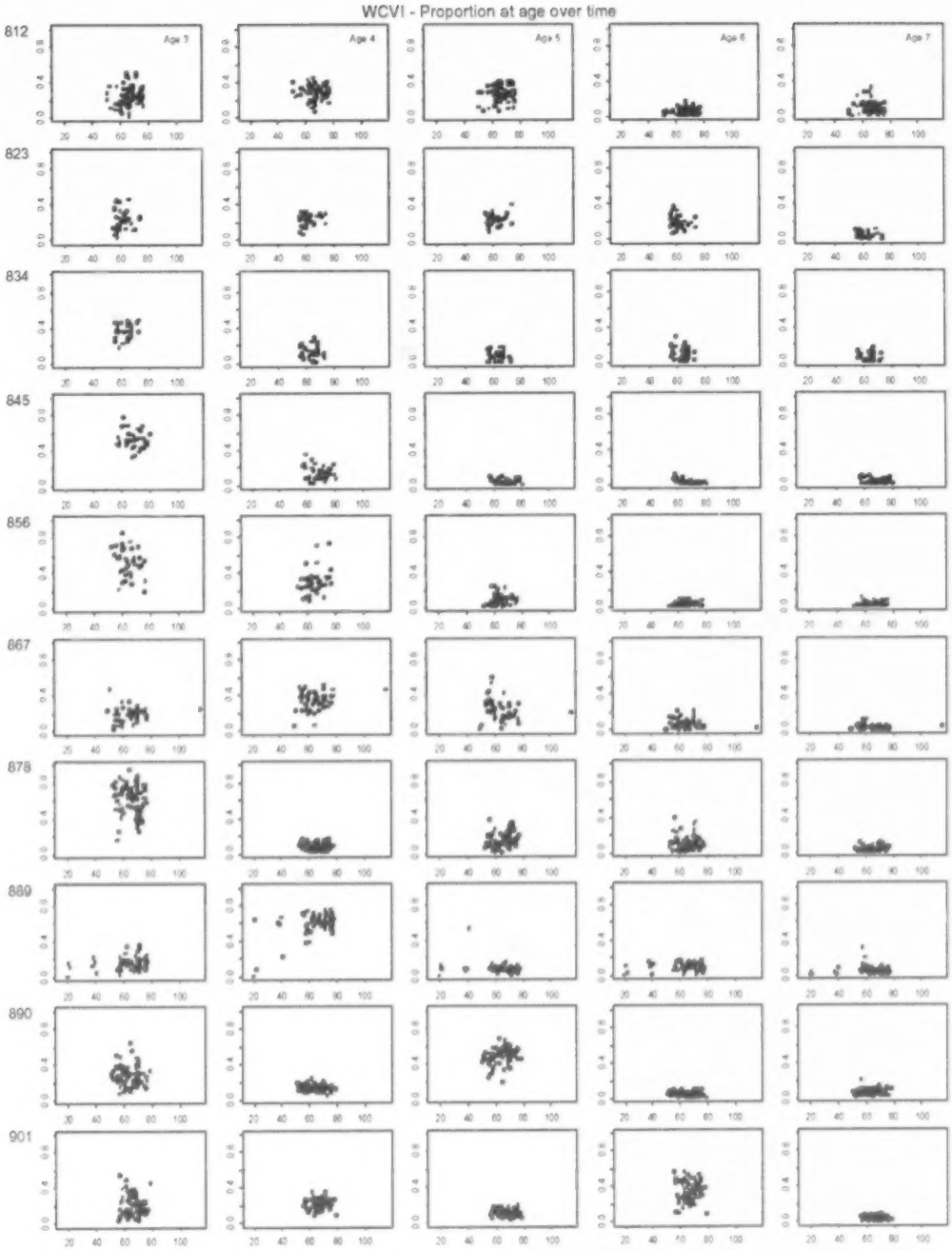
Appendix 3.4 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the Strait of Georgia from 1971-1999.



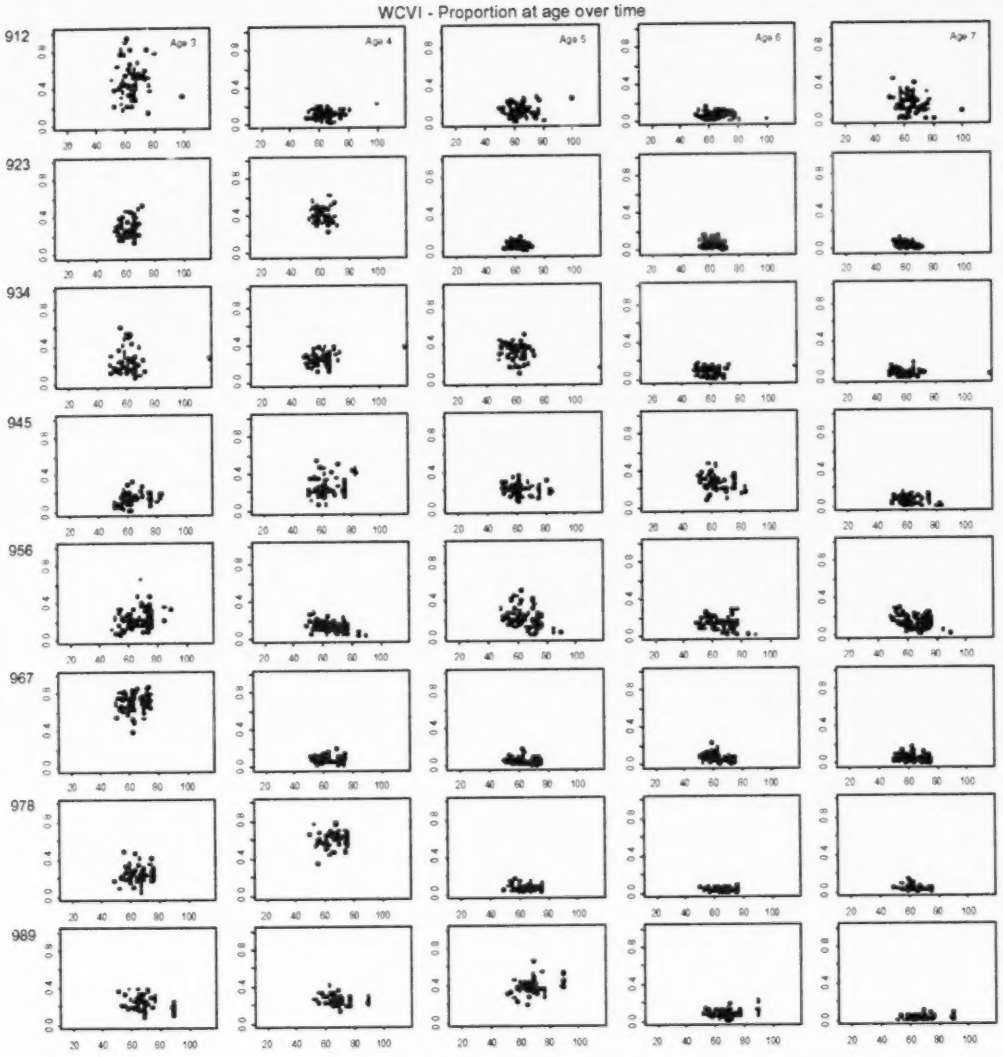
Appendix 3.4 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the Strait of Georgia from 1971-1999.



Appendix 3.5. Proportion of fish at ages 3 to 7 by sample and Julian day for the west coast of Vancouver Island from 1971-1999.



Appendix 3.5 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the west coast of Vancouver Island from 1971-1999.



Appendix 3.5 (cont'd). Proportion of fish at ages 3 to 7 by sample and Julian day for the west coast of Vancouver Island from 1971-1999.